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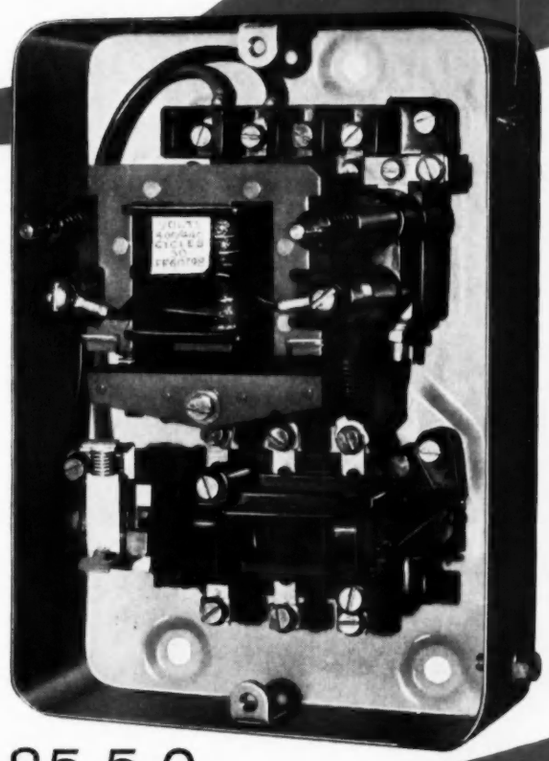

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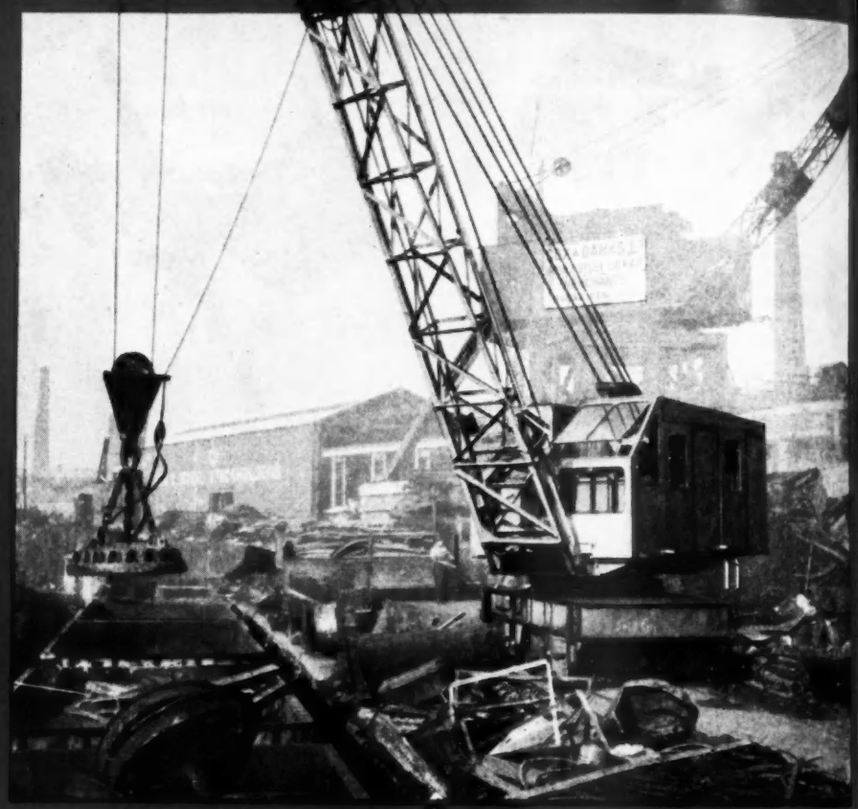

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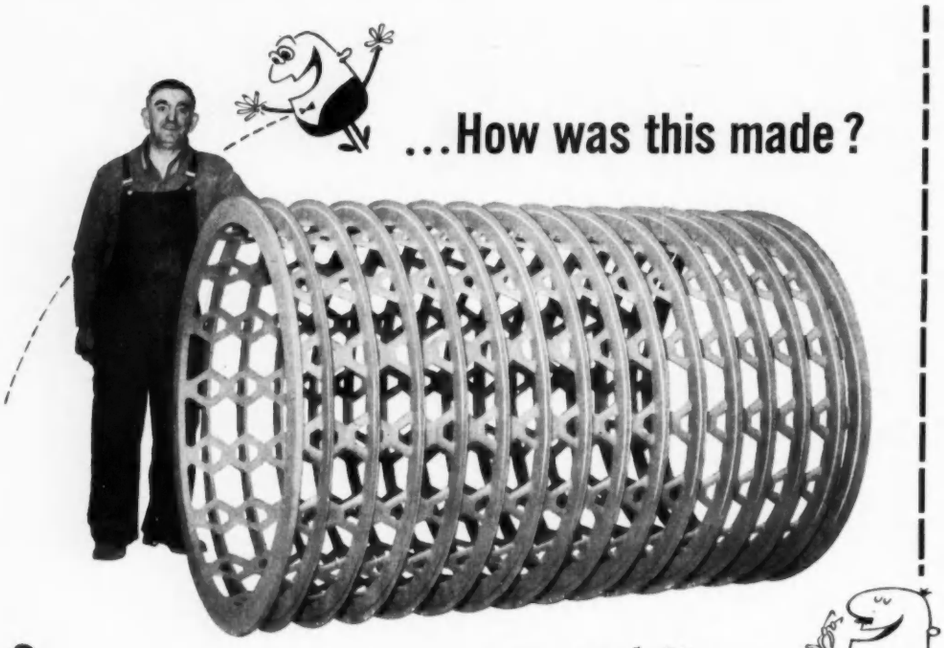

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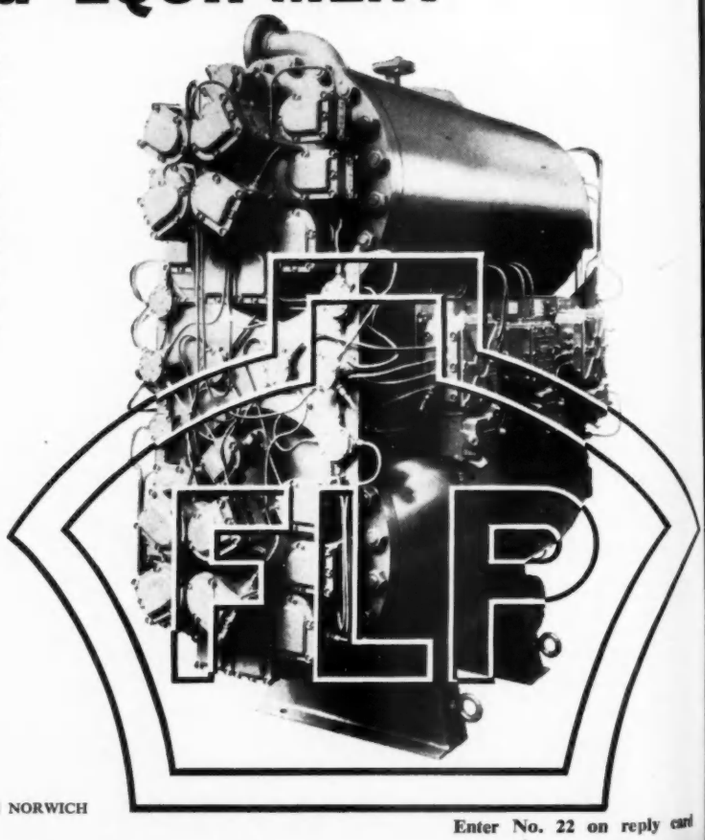

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No. 5487 MARCH 24, 1961 Vol. 211

BRAKE PERFORMANCE

Up to the present time there has been a lack of co-ordination of brake testing techniques between firms in the Motor Industry owing to the fact that the various procedures have not been founded on the fundamental principle of brake performance under actual road conditions. Papers presented before the Automobile Division of the Institution of Mechanical Engineers last week — see page 444 of this issue — successfully analyse brake usage and outline a suitable test procedure. But to obtain a perspective into which this new work fits it is necessary to review the background of brake testing as currently performed in the motor industry. In the course of developing new materials, the brake lining manufacturers have to evaluate the performance of their products comparatively and realistically before they can offer them to the trade. During such work they have come up against the problem of how severe to make their testing. They seem to be faced with a situation where there is an adverse overlap between the best materials which can be economically produced and the performance demand of their customers. This means there is a rather delicate balance between what is just good enough and the best that can be produced, not an uncommon thing to find in any engineering industry. Curiosity for technical truth coupled with commercial need prompted Ferodo, Ltd., to carry out some pioneer research into brake usage under road conditions a few years ago, and its findings were made public in papers by N. Carpenter and A. P. Lees. Vehicle manufacturers, for their part, have had since the war an expanding overseas market in which their vehicles have been used under conditions that their normal home market testing procedures did not always adequately cover. This situation has been coupled with a growth of average speed and traffic density at home. Increasing production also necessitated very thorough testing before release of specification, particularly as there is also competition between performance and cost of original equipment. Development departments endeavoured to meet the problems as they arose, and for these reasons the much discussed "repeated stop fade" test was evolved together with various other commonly used schedules. Brake component suppliers are, of course, also deeply involved in both fundamental testing and product performance analysis. In the three industries similar needs and some co-relation of ideas, propagated by means of occasional papers and technical contacts between users and suppliers, caused test techniques to be similar in form. But competition between firms has usually prevented the free exchange of views in time for test schedules to be compared and related before they are actually in use, and difficult to alter. This situation no doubt explains the difference of three to one which the authors of the papers have found exists in the severity of repeated stop fade tests. But it does not help the brake supplier who is in the invidious position of being the middle man, and who has to reduce, as best he can, all the various tests to a common meaning so as to be able to give rational advice. This is the prime reason why some standardised brake performance schedule is badly needed and also why the brake supplier is in the best position to carry out the necessary research and to propagate the results. Carpenter and Lees for Ferodo, Ltd., did most of the pioneering work which has had the effect of promoting understanding of the nature of the problem. The authors of the new work have applied this understanding, carried out extensive road testing and analysed the results to produce as an end product what is claimed to be a workable standard procedure based on road usage.

It should be emphasised that the paper is aimed at the upper limit of arduous road performance consistent with safety, and as such covers the worst conditions likely in practice. It replaces only the present fade test and leaves all other aspects of performance exactly as they are to-day. But it does bring into the fade picture a variety of energy, input and cooling periods which should highlight some of the other facets of behaviour. A number of speakers have asked how the proposals compare with the existing fade tests. Since the latter have been shown to vary by three to one, each questioner seems to mean, "how does it compare with the severity of our fade test?" Perhaps they should reverse this question and ask how their test compares with the authors'. Technically, energy inputs are easily compared and if the physical comparison is required only a test can give the answer. The acceptance level needs more discussion than it has had so far. Probably acceptance levels vary as much as the fade tests do, possibly in a direction causing a levelling out of results on competitive products. There could well be degrees of acceptance or rejection which would determine the further product development necessary. It is also not unreasonable that the tolerance of acceptance should be narrower for low energy parts of the test and widened a little, say, for the hill test on the stops from top speed. The method of examining the whole of the energy input part of the test seems preferable to rating acceptance by means of a single control test as is proposed in the Economic Commission for Europe (E.C.E.) regulations. Possibly the difference in outlook arises because the regulations require a "yes" or "no" answer, whereas an engineer wants to look at the whole qualitative picture. In any case the significance of repeatability of tests and scatter of results should be fully appreciated, though for obvious reasons it is seldom convenient to carry out many repeat tests. One therefore wonders how valid any "yes" or "no" answer can be. It would certainly be useful to see several similar cars tested to know how the scatter compares with, say, a timing change. People in the industry have expressed worry about the complication of the procedure advocated. But we suggest it should be tried out fairly and properly before it is criticised on this score.

Technical criticism seems to have centred around two main points. First, the factors from which the total

energies are derived are criticised, many people favouring power-to-weight ratio instead of either weight or maximum horsepower. Secondly the effect of engine braking is questioned. Both factors merit further examination, though of the two engine braking seems likely to cause the more serious error. It now remains for the findings to be put to the test of everyday production proving methods. It is suggested that the schedules be known as the MCH (1961) and Alpine (1961). This would designate them in a manner which leaves room for flexibility of development of procedure at subsequent dates, and does not mean that their introduction need be held back whilst finality is reached in committee. It is suggested that there is an urgent need for their introduction and no alteration should be discussed before it is done. Modifications might well be discussed by the S.M.M.T. and introduced as a development only if found necessary.

ELECTRICAL MANUFACTURERS

The annual report of the British Electrical and Allied Manufacturers' Association (B.E.A.M.A.) for 1960-61 leaves us with the impression that the outlook for the industry engenders optimism — but with some reservations. The optimism is based on the belief that, given reasonably stable conditions, the industry is organised and equipped to meet any foreseeable home demands and to meet foreign competition in overseas markets. The reservations — and they are very real ones — spring from the fact that the industry, like other engineering industries in Britain, has not in recent years enjoyed the favourable operating conditions of fiscal stability that an expanding industry needs.

That the electrical manufacturing industry is expanding and is capable of even more rapid expansion is clearly shown in the report. For example, the production of turbo-generating plant reached a new peak in 1960 when the capacity of plant delivered totalled 5146 MW, of which 36 per cent was exported. Technical progress is reflected by the fact that, while 200 MW generating sets are in operation with the C.E.G.B., much larger sets, of 550 MW each, are on order for installation in 1963. As a result it is expected that the capital costs of power stations will be reduced from about £50 to £40 per kW of plant installed. Such technical advances depend very much upon a strong research and development effort and it is estimated that the direct expenditure by the manufacturing industry on this effort is more than £64,000,000 annually. If allowance is made for the complementary effort exerted by other bodies, including the Electrical Research Association and the C.E.G.B., the total sum spent on research and development by the electrical industry is probably of the order of £80,000,000 per annum.

Such current expenditure on research and development can only be justified by a major industry which has substantial growth prospects and can engage in large scale and profitable production programmes. "Start-stop" policy changes of the kind applied recently to Britain's railway electrification and nuclear power programmes impose a severe handicap on an industry that has expanded its manufacturing potential to meet the demands of specific schemes. Accordingly B.E.A.M.A. has urged the Government to create and maintain stable conditions for the industry by approving and adhering to long term capital programmes. The effects of sudden reversals in Government fiscal policy are equally stringent on the domestic appliances industry. In October 1958 the complete removal of controls released an exceptional short-term demand which could not immediately be satisfied by British manufacturers and encouraged a flow of imported appliances. The reimposition of credit controls eighteen months later was, in the words of the B.E.A.M.A. report, "a damaging blow" to the industry. B.E.A.M.A. therefore strongly advocates a stable system of credit controls to avoid "alternating booms and depressions, artificially induced as a weapon of fiscal policy, which disrupt planning and increase unit costs of production to the detriment of exports." Motor-car manufacturers, too, have expressed similar views with equal force and clarity. It is encouraging, therefore, to learn that the President of the Board of Trade has agreed with B.E.A.M.A. that changes in credit control up or down are a dislocating factor in an industry with high capital investment. The President acknowledges the evil; we hope the Chancellor of the Exchequer is of the same persuasion.

WHAT IS THE FUNCTION OF THE NAVY?

The present position of nuclear stalemate has brought the realisation that conventional forces have again a vitally important job to do. Their task is to prevent a conflict over some question of policy developing by accident into an all-out suicidal war. How far either side would go before deciding to abandon its policy must remain a matter of opinion. But if the British taxpayer is enthusiastically to provide money for new ships, he must first understand what a warship has to do in various kinds of lesser scale wars, begun probably hundreds or even thousands of miles away from Home shores. He has always associated a type of ship — the battleship, cruiser, destroyer, frigate or submarine — with a definite function. And though certain types which he clearly recognised have disappeared, or are disappearing, he was encouraged — until three or four years ago — by successive First Lords of the Admiralty to believe that the cruiser of about 10,000 tons — a size originally limited by the 1921 Washington Treaty — was still required to safeguard the sea communications. But the past three weeks have made him still more confused. As reported by our naval correspondent in this issue, H.M.S. "Blake" — a cruiser of 9500 tons armed with fully automatic rapid-firing 6in guns, the third ship of the "Tiger" class — has recently been accepted for service and H.M.S. "Hampshire," a destroyer of between 5000 and 6000 tons — about 3500 tons larger than the largest modern destroyer — has just been launched at Clydebank. Moreover the order, revealed in the Navy Estimates, for two more vessels of this type and the gradual scrapping of wartime cruisers without replacement — only five now remain — clearly indicate that no more 6in gun cruisers, as they have been known hitherto, are to be built. In the light of the changed conditions of warfare at sea and the advent of the guided missile — United States warships are already equipped with the "Talos," a dual purpose guided missile, for use against ships as well as aircraft — it is surely necessary to reclassify ships according to function rather than armament. However, it may be said in passing that there are other reasons for the construction of the "Blake" and "Hampshire." The former was launched nineteen years ago and was more or less completed by the end of the war except for her armament. When, therefore, by 1954 a vastly improved 6in gun had become available, and in view of the ideas at that time on the conduct of naval warfare, it would have been a sheer waste of money not to complete the "Tiger" class. As for the "Hampshire," one can but

suspect, because Parliament is much averse from spending money on large ships in these nuclear days, that the Admiralty would have had difficulty in getting approval for this class of ship had she been called by any other name than a destroyer. Fortunately, the Admiralty seems satisfied that the modern 4·5in gun, which is to supplement her anti-aircraft guided missile armament, will be quite capable of dealing with 6in gun armed merchant raider — the most likely vessel to be used for surface attack against sea communications. There are indeed many matters on which the public could be enlightened by the First Lord or Civil Lord without detriment to security. The constant repetition that the Navy is ready for any kind of war does not help towards a better understanding of the Navy's functions. The First Lord has, it is true, explained that the carrier — or more specifically the commando carrier — is needed to support the Army in a "brush-fire" campaign. This, however, is not an immediate financial problem since none of Britain's existing carriers, all laid down during the war, will require replacement before 1970. But Britain is building nineteen frigates. Since she already has some eighty of these vessels, new or converted, available — primarily for anti-submarine duties — she seems to be expecting large-scale attacks on her sea communications from Soviet submarines rather than pin-pricks from Chinese or "Hottentot" underwater vessels. Is this likely without resulting in an all-out H-bomb war? Soviet military writers are allowed to state that they will use both H-missiles and conventional forces in an all-out war. But does Britain visualise this type of war when it has been officially stated that the British people cannot be protected against thermo-nuclear attack? Admiralty spokesmen would kindle much greater interest and enthusiasm for the Navy if they referred to matters of this kind. Neither they nor anyone else can foretell the limits of a lesser scale war. But they might well give their views on probabilities or at least explain in more detail the reasons for the types of ships, and their number, being built to-day.

CORROSIVE OCCASION

Ten years ago the inaugural meeting of the Corrosion Group of the Society of Chemical Industry was held in the Royal Institution, London. Since then there has passed a decade of ever wider and more scientific study of the nature, and the prevention, of corrosion, which has been helped along by many helpful discussions, a planned series of large symposia, and increased commercial publicity. Between April 10 and April 15 this year the First International Congress on Metallic Corrosion is to be held at the Imperial College of Science and Technology, South Kensington, with Sir Harry Melville, F.R.S., as its President. The Society of Chemical Industry which initiated and organised the Congress deserves the thanks of all users of metals and especially of engineers. It has succeeded in attracting and preprinting scientific papers from nineteen countries. Seventy of the authors come from overseas and fifty-seven are resident in the U.K.

How important is corrosion to engineers? Wherever a designer, dazzled by the wonders of mathematics, has overlooked the implications of electrochemistry, maintenance engineers have had quickly to report back to him that the road to progress is paved with corrosion troubles! The paramount significance of corrosion in the service life, and safety, of mechanisms is not easy to appreciate by those who find chemical explanations incomprehensible. Hence the need for the specialists now known as corrosionists, and the value of the many corrosion research teams that have only recently come into being. Marine engineers may well recall that "condenseritis" in the First World War, and marine boiler corrosion in the Second, occasionally immobilised ships badly needed in service. Corrosion has also played a baleful role in the aircraft, nuclear energy, and in the older gas, chemical engineering and petroleum industries.

The benefits are now being harvested from much very practical pioneering by co-operative committees such as those of the A.S.T.M., the Institute of Metals and the Iron and Steel Institute. Laboratory corrosion test procedures have benefited from many novel techniques, and the general knowledge of the subject has been built up by the Corrosion Group of the Society of Chemical Industry, and then spread out to the many specialists by technical journals, some of the more specialised of which, devoted to the study of corrosion and its prevention, made their first appearance during the past decade. Effective "conquests" of corrosion troubles have already been made in many fields of engineering, but in others much still remains to be discovered. Our electricity, for example, would be much more costly if the large boilers of great modern power stations corroded as badly as their smaller predecessors, before the development of corrosion-defeating chemical treatments and control of boiler waters was achieved. A similar achievement at sea makes the continued development of steam boilers for big ships possible, their corrosion inhibited. Only a decade ago the perforation of oil pipelines by corrosion was a very costly nuisance. But cathodic protection now holds it in check. Thus the science of metallic corrosion is earning dividends by its application in many industries. Mass-production has long been a catchword; but mass-preservation from ruin by corrosion is just as important. The First International Congress on Metallic Corrosion should do much to help engineers to design against those real corrosion problems that are still a hindrance to engineering practice and development.

The Engineer—100 Years Ago (MARCH 22, 1861)

"Railway Bridge Over the Rhine"

"The great railway bridge over the Rhine at Kehl being nearly completed, experiments to test its strength were made on it a few days back. First of all, the two turning parts of the bridge were manoeuvred, and were found to work admirably. That on the French side, which weighs not less than 350 tons, was moved with the greatest facility by eight men, then by four, and then by only two. Afterwards a train, consisting of five locomotives and their tenders, the locomotives alone weighing 175 tons and the whole forming a weight of nearly 3½ tons per meter, passed over the line, and then remained stationary on the first part of the bridge on the French side; next, a locomotive and fifteen wagons filled with stones, weighing about 1½ tons per meter, was driven over, and was subsequently stationed for a time in the middle of the bridge; in the third place, the two trains passed over side by side, and were made to stand on different fixed parts of the structure; next, two other trains, each consisting of five locomotives, were also driven over the bridge side by side, and were made to remain together some time on the turning bridges, and on other portions of the structure; lastly, these two trains crossed each other at full speed. During the experiments, the different parts of the bridge scarcely yielded, proving the correctness of the engineer's calculations, and the great care with which the bridge has been constructed."

Passenger Car Brake Testing

On Tuesday last week there were presented to the Institution of Mechanical Engineers in London two papers by A. E. Livsey, A. F. Prestidge, G.I.Mech.E.,* and D. F. Woor, B.Sc. (Eng.), A.M.I.Mech.E.,* in which were described research into the usage of passenger car brakes on four routes selected for the demands placed upon the brakes and a proposed test schedule to give a qualitative indication of the behaviour of the braking system. Parts of the papers are reproduced here.*

RESEARCH INTO BRAKE USAGE IN PASSENGER CARS

A TEST procedure for any product should represent practical operating conditions, with a suitable factor of safety. Vehicle brakes are expected to operate under a very wide range of conditions and the formulation of a test procedure to cover these presents a difficult problem. This has led to a number of different brake-test schedules being developed and used throughout the industry and, in particular, the existing " fade " test is one which exhibits the widest variations. These variations appear to be rather arbitrary in nature. Very little work on this subject has been published, the majority being given in papers by Carpenter[1] and Carpenter and Lees[2].

Since the ultimate objective was to derive a brake test schedule which would serve as a heavy duty assessment test for any particular vehicle-brake-lining combination, it was clear that concentration should be on the upper end of the brake performance and throughout the work all practical testing was carried out at the fastest possible speeds compatible with safety.

The selection of routes proved to be the most difficult part of the research because operating conditions vary so much throughout Great Britain and Europe that it would have been possible to arrange a programme that would have taken years to complete and the data obtained would have been outdated before it could be put to practical use. This fact, combined with the requirement of finally producing a test schedule based on severe brake-operating conditions, made it possible to reduce the types of motoring to be studied to four basic headings.

The four major headings finally decided upon were :

(1) Fast main-road motoring, typical in Great Britain. This was selected to study patterns of high-speed braking.

(2) Cross-country motoring on a winding road, typical of many runs undertaken in Great Britain, and one on which fair speeds could be obtained.

(3) Hill country, chosen for obvious reasons, but mainly because of the added effect of gradient when braking.

(4) Alpine descents, which involve an entirely different type of braking from section (3).

It must be emphasised that other workers in this field may suggest different types of route but, for reasons already stated, it was essential to reduce the studies to manageable proportions, and at the same time choose a typical cross-section of conditions which induce severe braking.

Analysis of Data

The two principal factors used in determining the brake usage are (1) energy dissipated by the vehicle during braking and (2) the manner in which it is dissipated. The first consists of calculating the energy dissipated during each check and then summing to obtain the total energy dissipated, and the second the analysis of the application and release speeds, together with the time intervals between the brake applications.

During the analysis several vehicle characteristics were examined in order to establish a relation between the vehicle and its brake usage. These consisted of the usual terms, such as brake horse-power per ton, engine capacity per lb of vehicle weight, to such terms as cubic centimetre per brake horse-power per ton, tractive effort, gear ratios and even a vehicle road holding or " handleability " factor.

For each route different characteristics appeared to provide sensible relations, and these are discussed in detail below. In every case it will be noted that the final curve on each figure is not a mean of the points plotted, but is such that when using the curves at a later date the most severe conditions of brake usage would be obtained.

On all the routes used for the investigation, the decelerations were in the order of 20–30 per cent of *g*, apart from the added effect of braking on a gradient, and rarely exceeded 40 per cent of *g*.

Main-road Running.—During main-road running high cruising speeds were maintained, these being approximately 85 per cent of the vehicle's maximum speed, the maximum speed being attained on several occasions,

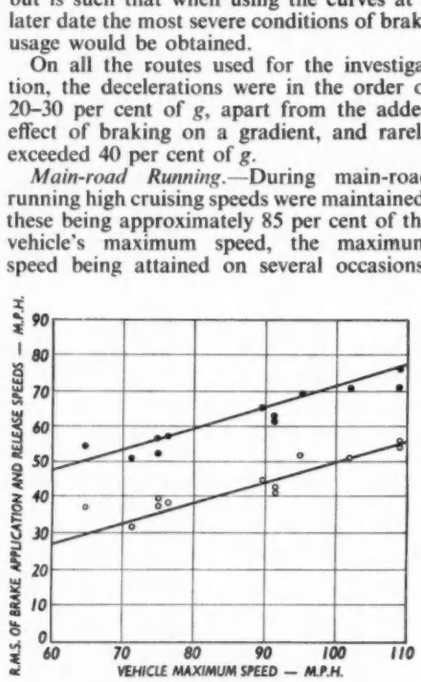


Fig. 1—Effect of maximum speed of vehicle on root mean square of brake application and release speeds for main-road running

and it was found that the brake usage bore some relation to the vehicle's maximum speed.

In Fig. 1 the r.m.s. value of the speeds at which the brakes were applied and released have been plotted against the vehicle maximum speed ; r.m.s. values were chosen since the kinetic energy dissipated varies as the square of the speed. This approach was used by Carpenter[1] in his investigation. The r.m.s. values of the brake application and release speeds increase with the vehicle's maximum speed, the two lines drawn running approximately parallel to each other.

It is evident from Fig. 2 that as the maximum speed of the vehicle increases so the journey-time decreases. Fig. 1, therefore, indirectly represents the r.m.s. of the brake application and release speeds plotted against the mean speed for the run. This result largely substantiates that found by Carpenter[1] who shows that as the mean journey speed of the vehicle increases the r.m.s. values of the brake application and release speeds follow the form shown in Fig. 1.

The curve drawn in Fig. 2 represents what is probably the minimum time in which the

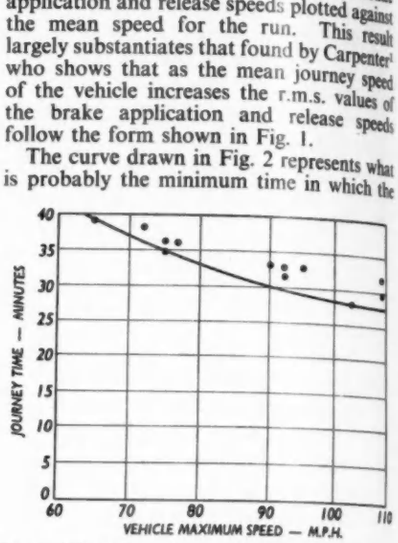


Fig. 2—Effect of maximum speed of vehicle on journey time for main-road running

vehicle can be expected to complete the journey, the curve tending toward a limiting value. This curve then establishes the total time for a test reproducing the worst conditions experienced.

The running time between the applications has been averaged and plotted against the vehicle maximum speed (Fig. 3). Although some points are above the minimum curve drawn, it was evident from the recordings that these corresponded to traffic-free conditions. It is suggested that if the normal traffic encountered had been present on these runs then the points would have approached the curve drawn. Fig. 1 indicates that these traffic checks have little effect on the r.m.s. values of the brake application and release speeds and journey time. Both ends of the curve tend toward a limit because, as the speed increases, there is obviously a maximum amount of braking that will be achieved and *vice versa*.

This completes the analysis of the fast main-road section, the graphs indicating that the brake usage varies mainly as the maximum speed of the vehicle for this type of motoring.

Cross-country.—On a winding route, in flat country, if the distance between the corners is such that when motoring to the maximum condition the vehicle is either accelerating between the corners or braking for the corners, then the energy dissipated whilst decelerating is some function of the

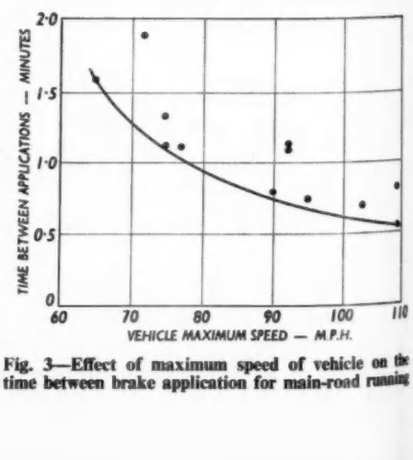


Fig. 3—Effect of maximum speed of vehicle on the time between brake application for main-road running

* Lockheed Hydraulic Brake Company, Ltd

kinetic energy gained during acceleration. The rate of kinetic energy increase whilst accelerating is dependent on the rate at which the engine can work, that is its brake horse-power.

From this reasoning it would seem that the engine brake horse-power is the variable upon which the rate of kinetic energy dissipation, that is total energy dissipated divided by run time, depends.

The particular run chosen consisted of braking sections of the nature mentioned above linked by sections involving braking to a lesser degree, and therefore the rate has been plotted against the engine brake horse-power (Fig. 4). The straight line drawn

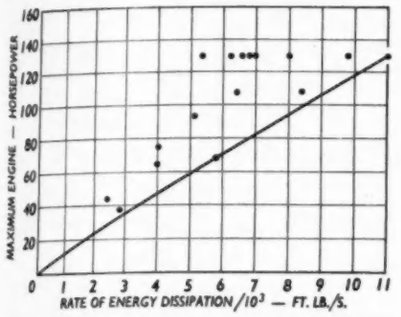


Fig. 4—Effect of engine horsepower on rate of kinetic energy dissipation for cross-country running

passes through zero and the maximum value obtained from the 130 h.p. car, and other vehicles approach this line. It is evident from the results of the 130 h.p. car that only one style of driving will promote these maximum conditions and it is suggested that the remaining vehicles, if driven in a similar manner, would increase their rate of energy dissipation and fall close to the line.

The time for the runs producing the points close to the line are within ± 1·5 minutes of 24·6 minutes which was the time for the 130 h.p. car. As the rate of energy dissipation is derived from the total energy dissipated, that is total energy divided by run time, it follows that as the run times on which the maximum rate was produced are almost constant, then the total energy dissipated on these runs must also bear a similar relation to the engine brake horse-power. This is shown in Fig. 5 where the total

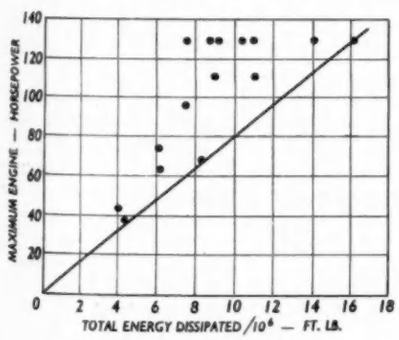


Fig. 5—Effect of engine horsepower on total kinetic energy dissipated for cross-country running

energy dissipated has been plotted for each individual car and it can be seen that the points that approached the line drawn in Fig. 4 again approach the line drawn through zero and the result of the 130 h.p. car. For all practical purposes then the maximum total energy dissipated on this run is proportional to the engine brake horse-power and can be taken to be dissipated in a time of 24·6 minutes.

In Fig. 6 the r.m.s. value of the brake

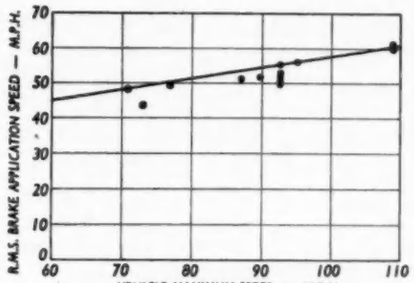


Fig. 6—Effect of maximum speed of vehicle on root mean square of brake application speed for cross-country running

application speeds have been plotted against the maximum vehicle speed. Whilst the maximum speeds vary from some 70 m.p.h. to 110 m.p.h. (a range of 40 m.p.h.) the variation of the r.m.s. value of the brake application speeds is only from 43 to 61 m.p.h. (a range of 18 m.p.h.). The line on this figure has been drawn at the higher application speeds rather than the average of the recorded results. This has been done in order to obtain some indication of the speed at which the vehicle should be braked from when the conditions experienced are simulated by a cyclic type of test.

This concludes the analysis of the cross-country section, the graphs indicating that the maximum energy dissipated varies as the engine horse-power and that the brake application speed varies as the maximum speed of the vehicle.

Hill Country.—When a vehicle is braked on an incline, both kinetic and potential energies are dissipated if a speed reduction occurs.

From the recorded data, the speed change, if any, during a brake application and the distance travelled on a particular gradient are known. The latter enables the vertical distance that the car has dropped through during the application to be calculated. By calculating the potential and kinetic energies dissipated and summing them the energy dissipated during each check is obtained. The addition of these values then gives the total energy dissipated for the run.

The descent times, apart from some traffic delays, were approximately constant for all cars, the nature of the route being such that high-power cars could not use their additional performance to much advantage. Periods of braking occurred in five definite groups corresponding to the five descents, there being little or no braking on the ascents.

The driving technique of the two drivers used for the investigation had little effect upon the number of checks, each driver braking at almost the same places on the route during the main part of the descents. Any difference that did occur in the number of applications was due to light checking incurred by traffic in some of the towns.

Having ascertained the average time of each descent and the average number of applications during this time, the average periodicity of checking for each descent can be calculated and is presented in Table II.

As neither the speed of which the vehicle was capable, nor the power developed by the engine, appeared to have any bearing upon the braking performances of the various cars during the descents, it was thought that the energy dissipated was probably proportional to the vehicle's weight. On a given incline the potential energy of the vehicle can vary only as its weight and as the descent times and number of applications did not show much variation from car to car, it is probable that the main factor affecting the kinetic energy dissipated is also the weight of the vehicle.

The total energy dissipated was calculated and plotted against the vehicle weight (Fig. 7). The curve drawn represents what is probably the maximum energy that could be dissipated on this route.

This concludes the analysis for the hill section and indicates that in hill running for practical purposes the maximum energy that can be dissipated depends on the weight of the vehicle.

Mountain Regions.—Experience on the Grossglocknerstrasse indicated that two entirely different types of descent of the pass would have to be studied. They were designated "traffic descents" and "clear descents." Both types of descent resolved themselves into two sections: the first part of 8·5 miles, the second of 3·6 miles. The first necessitated a third-gear descent, but the second could be negotiated in top gear.

The details of two of the runs conducted with the two cars are given in Table III. The large number of applications recorded

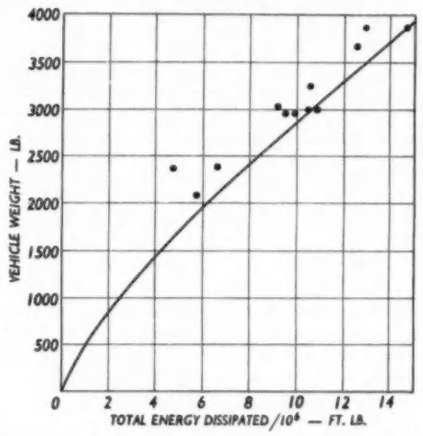


Fig. 7—Effect of weight of vehicles on total energy dissipated for hill running

on run 1 of car N is due to the fact that this descent was carried out in the dark, necessitating a considerable number of light checks. It is interesting to note that, in spite of the increase in applications, the energy dissipated and the time for the descent compare with the results obtained when less checks occurred in daylight descent. This would seem to indicate that with a clear descent the type of driving appears to have little effect upon the total and average rate of energy dissipated when a fairly fast descent, with due regard to safety, was made. When descents were made in traffic the energy dissipated was not as great, this being due to the reduction in speed necessitated by the traffic. The maximum conditions recorded for each car show a good degree of consistency, and it is thought that these would be difficult to exceed under general motoring conditions.

It must be emphasized that the analysis is based upon somewhat limited information, namely, only two cars, but it is considered that all cars will return similar results of brake usage and, therefore, the energy dissipated will vary directly with the weight of the vehicle for this type of descent. This supposition is based on observation of other vehicles on the pass.

Conclusions

On fast main-road motoring (excluding motorways and their continental equivalents) maximum brake usage varies as the maximum speed of the vehicle, whereas on winding

cross-country roads the pattern and amount of braking varies as the maximum speed and engine brake horse-power available. Obviously, the handleability of a car must affect the brake usage to some extent, but as no common factor on this point could be found throughout the research, it must be assumed that the car designer has already determined handling characteristics, and this work was undertaken to find out how brake usage varied in existing motor cars.

In hill and mountainous country the weight of the vehicle most affects the energy dissipated by the brakes, the pattern of braking being similar for all passenger cars.

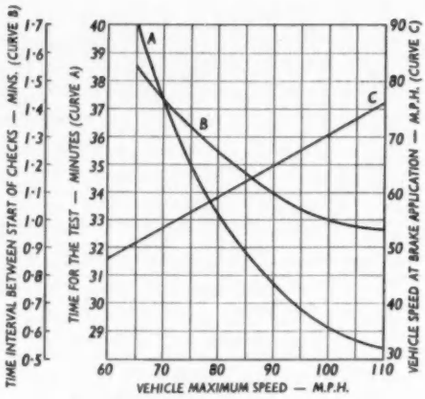
A TEST SCHEDULE FOR PASSENGER-CAR BRAKES

The basic thought underlying the formulation of this schedule was that if a test is to simulate road conditions with a fair degree of accuracy it must do more than just dissipate a certain amount of energy in a given time. The brake applications should be similar to those experienced on the road and this obviously rules out a series of stops with the transmission in neutral, which is the method adopted in many existing fade tests. However, an immediate problem occurs, because it is impossible to carry out a brake test on the public roads, and therefore the test must be undertaken on a private track with corners to be negotiated. This raises the question of the speed at which the brakes must be released. It has been found that on most tracks the corners can be safely negotiated at 30 m.p.h. The tests are therefore derived taking 30 m.p.h. as the release speed. Unfortunately, this is something which does not occur in road usage, but it is a decision which has had to be taken because of the nature of the tracks available for testing. In the unlikely case of track limitations enforcing lower release speeds the tests can be modified to accommodate this, provided the same average rate and total energies are dissipated. This should be done by modifying the time intervals between the applications so that the same initial rate of energy dissipation is maintained at the start of each check.

The test schedule to replace the existing fade test is derived by building up from the various road sections studied previously. For a number of reasons it was finally decided that two tests were necessary : one based on the first three sections studied, namely, Main-road, Cross-country and Hill-country, and the second based on the Alpine descent. Throughout the paper the first test is referred to as the " MCH " test, these letters being the initial letters of the three road sections included in the test, and the second one is referred to as the Alpine test. Initially, each section is considered separately and then the final schedule is built up in a later section of the paper.

Fast Main Road.—The curves shown in Fig. 8 give the total time for the test (curve *A*), the running time between the start of the checks (curve *B* modified), and the vehicle speed at brake application (curve *C*) for any car, the independent variable being the maximum speed of the vehicle. The time between the start of checks has been modified in order to maintain a similar rate of energy dissipation when the brake-release speed is kept constant at 30 m.p.h. The number of checks is obtained by dividing the total test time by the time interval between the checks.

The decelerations recorded for this type of motoring were in the order of 20–30 per cent of *g*, and consequently, 30 per cent of *g* is taken as the datum value for this section


TIME INTERVAL BETWEEN START OF CHECKS — MINS. (CURVE B)
TIME FOR THE TEST — MINUTES (CURVE A)
VEHICLE SPEED AT BRAKE APPLICATION — M.P.H. (CURVE C)
VEHICLE MAXIMUM SPEED — M.P.H.
A
B
C

A Total time for test.
B Running time between checks (modified).
C Speed of vehicle at brake application.

Fig. 8—Curves for main-road section

of the test. However, for reasons stated later, when the complete MCH test is built up, certain 50 per cent of *g* stops and checks are included.

Cross-country.—From the analysis of this type of motoring[1] the following information is known (Table I) :

(1) The total time for the run for maximum braking conditions.

(2) The total energy to be dissipated.

(3) The vehicle speed at brake application.

From the braking speed and car weight the kinetic energy per check can be calculated as follows :

Energy dissipated per check $=\frac{1}{2}M(v^2-u^2)$ ft lb, where $M=W/g$ (vehicle mass), v vehicle speed at brake application, and u is vehicle speed at brake release.

If v and u are m.p.h., u being taken as 30 m.p.h. and W in lb, the equation becomes

$$\text{energy dissipated per check} = 0{\cdot}0334W(v^2-900) \text{ ft lb.}$$

By dividing the total energy to be dissipated by the energy dissipated per check the number of checks is obtained, and if the total time is then divided by the number of checks, the periodicity of the checks is known.

Let the vehicle test weight be W, lb, its engine horse-power T, brake horse-power, and maximum speed S, m.p.h.

TABLE I—*Relations Obtained from Cross-Country Running*

Total time for the test	24·6 minutes = 1476 seconds
Total energy to be dissipated... ...	Gross brake horse-power $\times 0{\cdot}1255 \times 10^6$ ft lb
Vehicle speed at brake application	(Vehicle maximum speed $\times 0{\cdot}317) + 25{\cdot}3$ m.p.h.)

Then from the relations given in Table I, the evaluation of the test is as follows :

(1) Total time for the test = 24·6 minutes = 1476 seconds.

(2) Total energy to be dissipated $= T \times 0{\cdot}1255 \times 10^6$ ft lb.

(3) Vehicle speed at brake application $= (S \times 0{\cdot}317) + 25{\cdot}3$ m.p.h.

(4) Energy dissipated per check $= 0{\cdot}0334W(v^2-900)$ ft lb.

(5) Number of checks

$$= \frac{\text{total energy dissipated}}{\text{energy dissipated per check}} = \frac{(2)}{(4)}$$

(6) Periodicity $= \frac{\text{total time for the test}}{\text{number of checks}} = \frac{(1)}{(5)}$

The deceleration for this section of the test will be similar to that of the main-road section, namely 30 per cent of *g*, with modifications to 50 per cent of *g* as explained later.

Hill Country.—From Fig. 9 and Table II the average number and periodicity of the applications, the time intervals between the braking periods and the total energy to be dissipated are known for this type of motoring. The only factor that remains to be found is the brake application speed which

TABLE II—*Results of Hill Country Running*

Hill	1	2	3	4	5	Total
Average number of applications	17	9	10	14	12	62
Average periodicity of applications, seconds	16	23	15	18	18	
Time interval to braking period, nearest half minute	4	3·5	2·5	5	2	

will reproduce the same energy dissipation and this is calculated in the following manner :

From Table II the total number of checks is sixty-two, and therefore the energy dissipated per check is :

$$\frac{\text{total energy to be dissipated}}{62} = 0{\cdot}0334W(v_1^2-u^2)$$

where v_1 is the vehicle speed at brake application and, u being 30 m.p.h., gives

$$v_1 = \left(900 + \frac{\text{total energy dissipated}}{2{\cdot}075W}\right)^{\frac{1}{2}}$$

The total energy dissipated is obtained from Fig. 9.

This section of the MCH test resolves itself into five periods of braking, representing the descents, separated by four cooling periods, representing the ascents. During the run, applications down to zero occurred at the end of descents 3 and 5, so the last brake application of these periods is down to rest instead of 30 m.p.h.

The majority of the applications recorded during the investigation were of the order of 30 per cent of *g*, with some checks up to 40 per cent of *g* deceleration. In order to cater for these maximum conditions, 40 per cent of *g* has been taken as the datum. From the above, however, it is only fair to conduct some of the checks at 30 per cent of *g*. Therefore, the decelerations used in this section of the test have been varied. Some periods of braking are to be conducted at 40 per cent of *g* and others at 30 per cent of *g* deceleration.

Alpine Descent.—Some of the details of various descents of an Alpine pass are given

TABLE III—*Details of Alpine Pass Descent*

Car	Number of checks		Energy dissipated on descent, ft lb/10⁶		Time for each section, minute	
	Third-gear section	Top-gear section	Third-gear section	Top-gear section	Third-gear section	Top-gear section
N ...	119	21	10·62	2·274	22·6	6·09
	86	18	11·04	2·115	22·1	6·18
M ...	87	21	12·92	3·602	22·8	6·05
	99	25	13·23	3·205	22·1	6·80

in Table III. It can be seen that the maximum energy dissipated by each car in each section occurs on different runs ; thus as the energy difference for each similar section is very small the averages were taken and are as follows :

	Third-gear part of descent, energy, ft lb/10⁶	Top-gear part of descent, energy, ft lb/10⁶
Car N	10·83	2·194
Car M	13·07	3·403

The times for each car and the number of applications within each section are comparable apart from the particular case of the 119 checks for car *N*. These extra checks were incurred due to the run being carried out in the dark, necessitating an additional number of applications. As the test will resolve itself into one of almost continual braking, the actual number of checks is not of major importance when compared to the total energy to be dissipated within a given time. Thus the number of checks and the time within each part of the descent has been

averaged for the four runs, the resulting checks and periodicity being as follows :

	Third-gear part of descent	Top-gear part of descent
Average number of checks	98	21
Average periodicity of checks, seconds ...	14	18

Knowing now the number of checks, the energy to be dissipated and the brake release speed (that is, 30 m.p.h.), the brake application speed can be determined in the same manner as in the hill section. The resultant speeds (in m.p.h.) are :

	Third-gear part of descent	Top-gear part of descent
Car N	43·24	45·59
Car M	44·11	43·46

From the above it would appear that within reasonable limits the speeds at brake application are similar for both cars. Thus weight is the major factor affecting energy dissipation, especially in the third-gear part of the descent. Therefore, the test parameters are the same for all passenger cars, the speed at brake application being taken as the average of the four speeds quoted above, that is, 44 m.p.h.

The time schedule for this test is such that decelerations of at least 40 per cent of g are necessary in order to carry out the third-gear section of the test. This is imposed by vehicle acceleration and driver capability, and is one of the penalties resulting from converting hill braking to flat track conditions. This deceleration, whilst increasing the rate of energy input per application, will have the effect of changing the initial rate of temperature increase, but will cause little change in the maximum temperatures. This has been shown by Newcomb[3].

The time schedule for the top-gear section of the test is not as severe and allows a lower deceleration, that is, 30 per cent of g, to be used.

MCH Test : Complete Schedule.—It is suggested that the three tests representing the main-road, cross-country and hill work

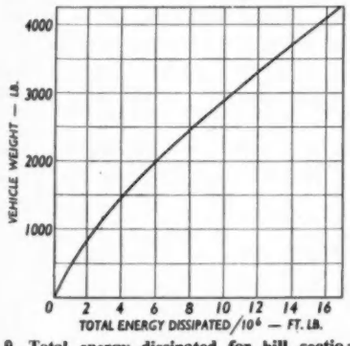


Fig. 9—Total energy dissipated for hill section of MCH test

should run concurrently as this could occur in practice.

The order in which the sections are conducted is as follows :

(1) Main-road ; (2) Cross-country ; (3) Hill country ; (4) Half main-road.

This places the three sections in order of severity and should give the worst conditions of test. Half of the main-road section has been added at the end to assess the performance of the brake and lining after a period of heavy braking.

During the main-road and cross-country running some stops were encountered, and these are inserted at the beginning and end of the two sections. The car speed at which the brakes are applied for the stops has been taken as its cruising speed and has been found to be approximately 85 per cent of the vehicle's maximum speed.

The road running produced no emergency applications, but these must obviously be catered for. To do this and also to provide some measure of the ability of the braking system to continue to produce decelerations of an emergency nature as the test proceeds, the stops mentioned above, and also every sixth application of the main-road and cross-country sections are made at 50 per cent of g deceleration.

Combining the three sections the test takes the form stated below :

All the brake applications are to be conducted in top gear, so reproducing road running conditions.

The values of X, Y, and Z are obtained as indicated in the main-road section, U, v, and Q as in the cross-country section, and v_1 as in the hill section (Appendix).

(1) One stop from 85 per cent of the vehicle's maximum speed at 50 per cent of g deceleration.

(2) X checks from Y m.p.h. to 30 m.p.h. with a Z seconds interval between the start of each check. Deceleration to be 30 per cent of g, with every sixth check at 50 per cent of g.

(3) One stop from 85 per cent of the vehicle's maximum speed at 50 per cent of g deceleration.

(4) U checks from v m.p.h. to 30 m.p.h. with a Q seconds interval between the start of each check. Deceleration to be 30 per cent of g, with every sixth check at 50 per cent of g.

(5) One stop from 85 per cent of the vehicle's maximum speed at 50 per cent of g deceleration.

(6) Four minutes cooling at 30 m.p.h.

(7) Seventeen checks from v_1 m.p.h. to 30 m.p.h. with a 16 seconds interval between the start of each check. Deceleration to be 40 per cent of g.

(8) Three-and-a-half minutes cooling at 30 m.p.h.

(9) Nine checks from v_1 m.p.h. to 30 m.p.h. with a 23 seconds interval between the start of each check. Deceleration to be 30 per cent of g, except the first check, which is to be 40 per cent of g.

(10) Two-and-a-half minutes cooling at 30 m.p.h.

(11) Nine checks from v_1 m.p.h. to 30 m.p.h. with a 15 seconds interval between the start of each check. Deceleration to be 30 per cent of g.

(12) One stop from v_1 m.p.h. at 30 per cent of g deceleration.

(13) Five minutes cooling at 30 m.p.h.

(14) Fourteen checks from v_1 m.p.h. to 30 m.p.h. with an 18 seconds interval between the start of each check. Deceleration to be 40 per cent of g, except the first check, which is to be 30 per cent of g.

(15) Two minutes cooling at 30 m.p.h.

(16) Eleven checks from v_1 m.p.h. to 30 m.p.h. with an 18 seconds interval between the start of each check. Decleration to be 40 per cent of g.

(17) One stop from v_1 m.p.h. at 40 per cent of g deceleration.

(18) $X/2$ checks from Y m.p.h. to 30 m.p.h. with a Z seconds interval between the start of each check. Deceleration to be 30 per cent of g, with every sixth check at 50 per cent of g.

(19) One stop from 85 per cent of the vehicle's maximum speed at 50 per cent of g deceleration.

Items 6–17 constitute the hill section of the test, and where there is a change in declaration from one braking period to the next, the deceleration of the first check of the second period has been made the same as for the last check of the previous period, so that a direct comparison is available after the cooling interval.

Alpine Test.—The test, as already stated, is the same for all cars, and is as follows :

(1) Ninety-eight checks from 44 m.p.h. to 30 m.p.h. with a 14 seconds interval between the start of each check. Deceleration to be 40 per cent of g. All checks to be made in third gear (or second on a three-speed gear box).

(2) Twenty-two checks from 44 m.p.h. to 30 m.p.h. with an 18 seconds' interval between the start of each check. All checks to be made in top gear using 30 per cent of g deceleration.

Method of Test

A step-by-step procedure from test initiation to the final analysis of the brake performance during MCH and Alpine tests is given. This procedure is illustrated by taking the example of a typical medium-size car.

Vehicle Data.—The data required is the vehicle weight, its top speed, and gross engine brake horse-power. It is suggested that the vehicle weight should include a full complement of passengers (150 lb each), luggage (28 lb per passenger), a 4 per cent increase in vehicle weight due to accumulation of road dirt, and a full tank of petrol.

These data for the example considered are : (*a*) Test weight, 2958 lb ; (*b*) gross engine brake horse-power, 51; (*c*) maximum speed, 79 m.p.h.

Calculation of Tests.—MCH Test.—Use the above data in the graphs and formulae derived in the preceding sections, and the values X, Y, Z, U, v, Q and v_1 are obtained. This process is given in detail in the Appendix. The values obtained are substituted in the combined test schedule,

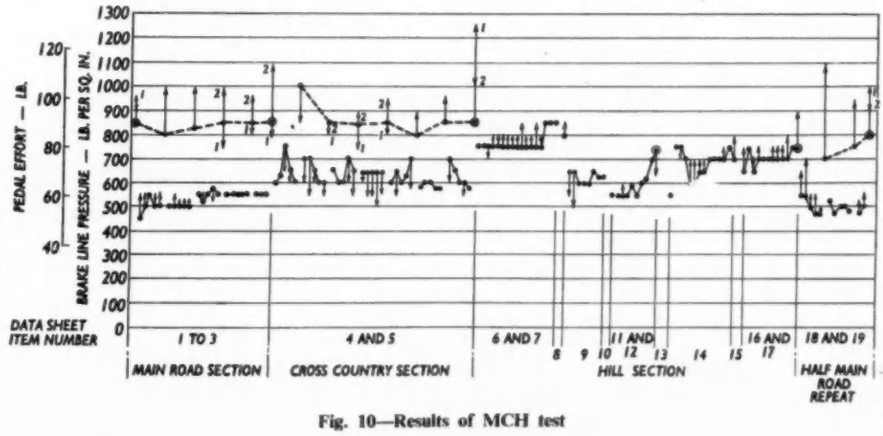


Fig. 10—Results of MCH test

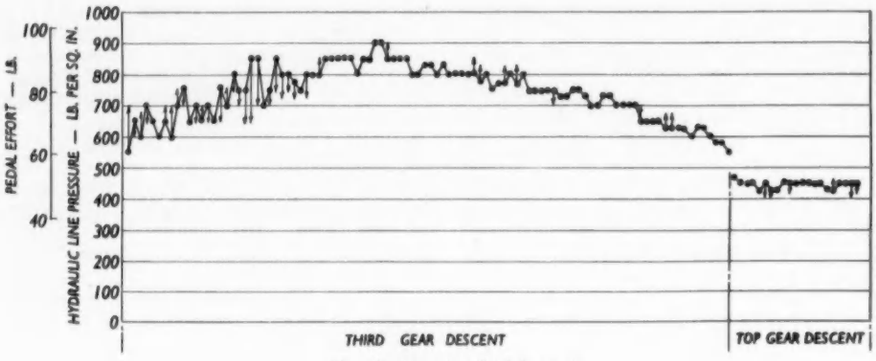


Fig. 11—Results of Alpine test

TABLE IV

Vehicle weight 2958 *lb*

MCH TEST

(1) One stop from 67 m.p.h. at 50 per cent of *g*.
(2) Twenty-seven checks, one every seventy-five seconds, from 59 to 30 m.p.h. at 30 per cent. of *g*, with every sixth at 50 per cent of *g*.
(3) One stop from 67 m.p.h. at 50 per cent of *g*.
(4) Forty-one checks, one every thirty-six seconds, from 50 to 30 m.p.h. at 30 per cent of *g*, with every sixth at 50 per cent of *g*.
(5) One stop from 67 m.p.h. at 50 per cent of *g*.
(6) Four minutes cooling at 30 m.p.h.
(7) Seventeen checks, one every sixteen seconds, from 51 m.p.h. to 30 m.p.h. at 40 per cent of *g*.
(8) 3½ minutes cooling at 30 m.p.h.
(9) Nine checks, one every twenty-three seconds, from 51 to 30 m.p.h. at 30 per cent of *g*, except the first which is at 40 per cent of *g*.
(10) 2½ minutes cooling at 30 m.p.h.
(11) Nine checks, one every fifteen seconds, from 51 to 30 m.p.h. at 30 per cent of *g*.
(12) One stop from 51 m.p.h. at 30 per cent of *g*.
(13) Five minutes cooling at 30 m.p.h.
(14) Fourteen checks, one every eighteen seconds, from 51 to 30 m.p.h. at 40 per cent of *g*, except the first which is at 30 per cent of *g*.
(15) Two minutes cooling at 30 m.p.h.
(16) Eleven checks, one every eighteen seconds, from 51 to 30 m.p.h. at 40 per cent of *g*.
(17) One stop from 51 m.p.h. at 40 per cent of *g*.
(18) Fourteen checks, one every seventy-five seconds from 59 to 30 m.p.h. at 30 per cent of *g*, with every sixth at 50 per cent of *g*.
(19) One stop from 67 m.p.h. at 50 per cent of *g*.

ALPINE TEST

(1) Ninety-eight checks, one every fourteen seconds, from 44 to 30 m.p.h. at 40 per cent of *g* deceleration, and in third gear (or second on a three-speed gearbox).
(2) Twenty-two checks, one every eighteen seconds, from 44 to 30 m.p.h. at 30 per cent of *g* deceleration, in top gear.

resulting in a data sheet as shown in Table IV.

Alpine Test.—This test is the same for all saloon motor cars and appears on the data sheet, Table IV.

Instrumentation.—The necessary instruments are a calibrated speedometer, a direct-reading decelerometer (for example a U-tube), a brake-line pressure gauge or pedal pressometer, and a stopwatch. Additional items often required are thermocouples and temperature-indicating paints for disc or drum on both front and rear brakes, and a pedal travel meter. If information on lining wear is required, then it is often convenient to measure the linings whilst the above instruments are being fitted.

The tests are normally carried out using one observer.

Method of Test.—A sheet is prepared giving details of each application. The car is then motored round the track and braked accordingly, each result being entered on the prepared sheet and the next requirement given to the driver without delay. This process is continued until the completion of the MCH test. It is desirable at this stage to do some form of recovery test to complete the temperature cycle. The car is then given a period of road running to normalise the linings after this hard work ; an Alpine test can then be conducted if it is required.

RESULTS

The results of MCH and Alpine tests carried out on the example given are shown in Figs. 10 and 11 respectively. The points on the graphs represent the line pressure necessary to achieve the decleration required for a particular application. The arrows away from these points represent a rise or fall in the pressure, to the value at the arrow head, necessary to maintain the deceleration. Where a rise and fall occur during a check, two arrow heads are shown and are numbered in their order of occurrence. Within each section of the tests, the points representing the same decelerations have been joined together by straight lines, and points representing applications down to rest have been enclosed in a circle. These artifices have been used to facilitate identification of the various groups of brake applications within a section.

INTERPRETATION OF RESULTS

An ideal braking system may be defined as one in which the pedal effort to obtain a predetermined percentage of *g* deceleration at any time will not be affected by the speed of the vehicle, the temperature of the brake, nor the previous work performed. Furthermore, the percentage of *g* deceleration will vary directly as the pedal effort in the ideal system. When analysing the performance of a braking system, the deviation from the ideal is automatically considered, that is, the fade in a brake from a performance aspect is merely the increase in pedal effort above a predetermined standard. Conversely, sharpness is the decrease in pedal effort below the standard. Thus, it is suggested that the results (as pedal efforts) of an MCH or Alpine test which contain brake applications at a number of different deceleration levels should be presented in terms of a reference pedal effort ; this gives an immediate comparison to a predetermined standard of the results obtained throughout a test representing road conditions.

A convenient method of presenting the results on this basis is shown in Fig. 12*a* and *b*, which refer to the MCH and Alpine tests respectively, and it is suggested that these are called " unity graphs " for ease of definition. All pedal efforts are related to the average of those obtained from the 30 per cent of *g* decelerations during the main-road section of the test. This datum was selected as the main-road part most closely represents normal running conditions. All the pedal efforts throughout the whole test are then converted to the equivalent for 30 per cent of *g* deceleration as a direct ratio. These " equivalent " pedal efforts are plotted as a percentage change of the datum.

It is thus obvious that curves presented on this basis give a ready means of assessing whether the brake performance under simulated road conditions (including varying decelerations) is within acceptable limits.

Fig. 13 shows the unity graphs plotted from the results of MCH tests carried out during normal development testing on a particular saloon car fitted with different linings. For each test, all conditions were identical, the only difference being the lining material itself. From these results the reaction of each lining material to the varied conditions of test is readily seen, and a reasonable comparison between the merits and disadvantages of the materials may be made.

APPENDIX

EXAMPLE OF MCH TEST

Vehicle data :
Vehicle test weight, 2958 lb.
Gross engine brake horse-power, 51.
Vehicle maximum speed, 79 m.p.h.
85 per cent of vehicle maximum speed, 67 m.p.h.

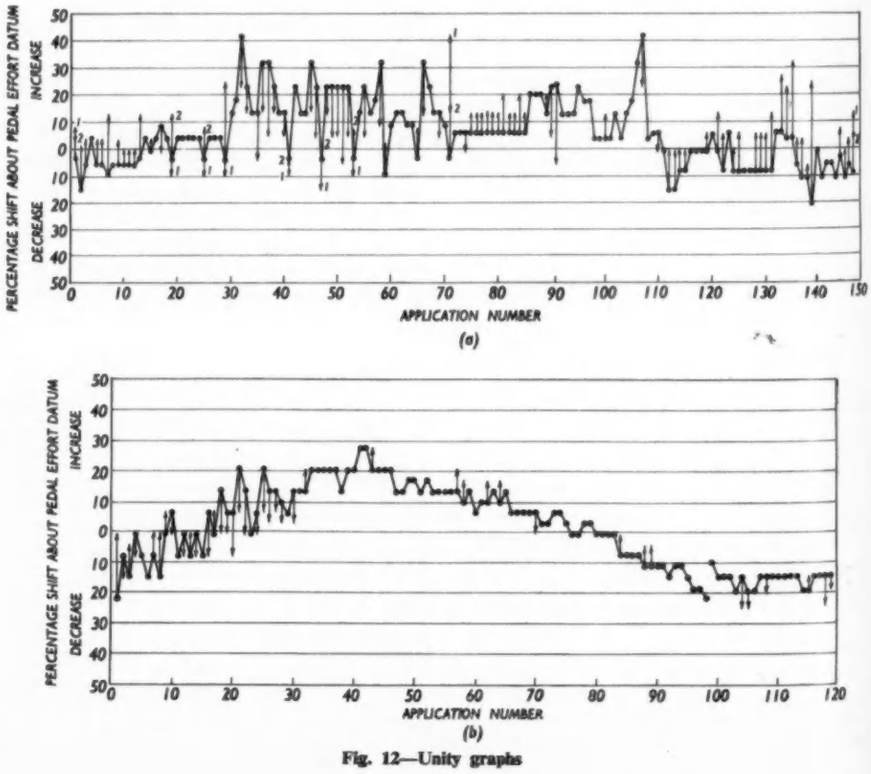


Fig. 12—Unity graphs

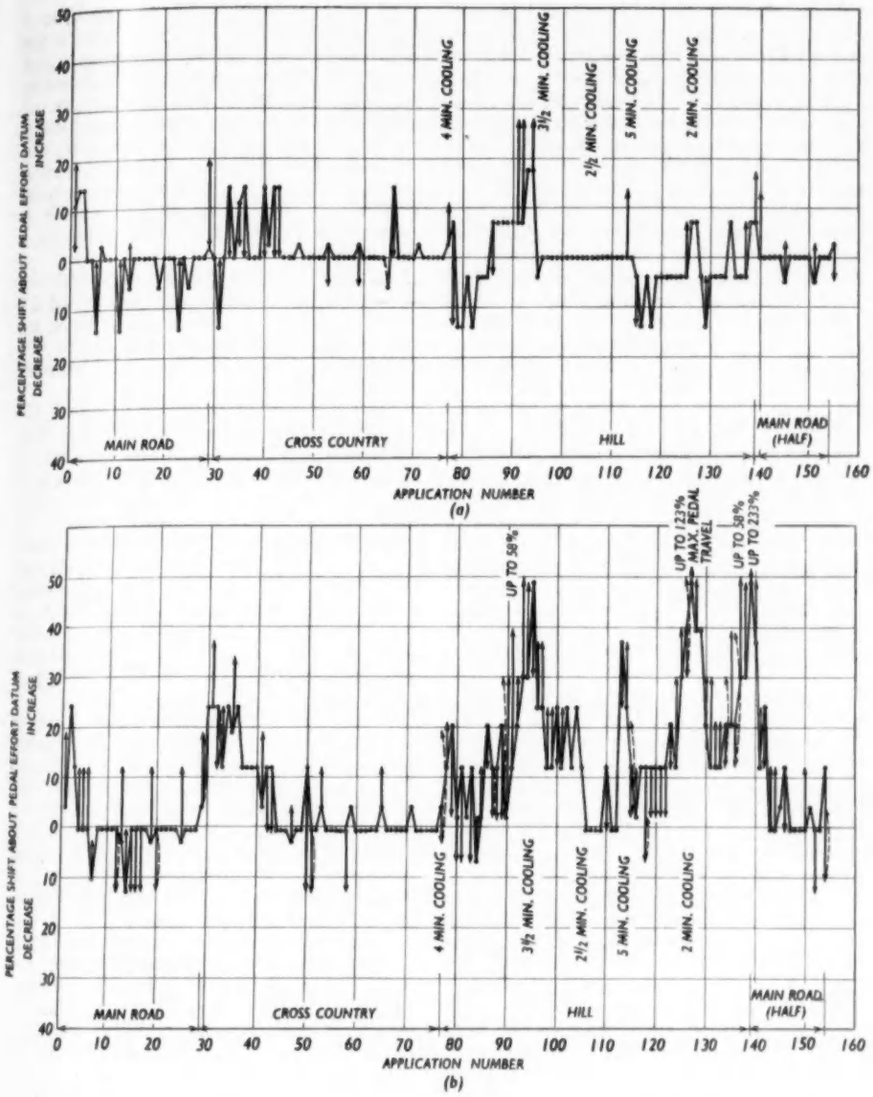


Fig. 13—Unity graphs of results of MCH tests on a particular car fitted with different linings

Main-road section :

From Fig. 8,

(1) Total time for the test, 33·6 minutes.

(2) Time interval between start of checks, 75 seconds $= Z$.

(3) Vehicle speed at brake application, 59 m.p.h. $= Y$.

(4) Number of checks, $\frac{a}{b} = \frac{33 \cdot 6}{1 \cdot 25}$
$= 26 \cdot 9$ (say, 27) $= X$.

The test for this section is twenty-seven checks from 59 m.p.h. to 30 m.p.h. every seventy-five seconds at 30 per cent of g deceleration with every sixth check at 50 per cent of g deceleration.

Cross-country section :

(1) Vehicle speed at brake application
$= (0 \cdot 317 \times 79) + 25 \cdot 3$
$= 50 \cdot 35$ (say, 50) m.p.h.
$= v$

(2) Total energy dissipated
$= 51 \times 0 \cdot 1255 \times 10^6$ ft lb
$= 6 \cdot 4 \times 10^6$ ft lb

(3) Energy dissipated per check
$= 0 \cdot 0334\ (50^2 - 30^2) \times 2958$ ft lb
$= 158{,}000$ ft lb

(4) Number of checks
$= \frac{b}{c} = \frac{6 \cdot 4 \times 10^6}{158{,}000}$
$= 40 \cdot 6$ (say, 41) $= U$

(5) Periodicity of checking
$= \frac{1476}{41} = 36$ seconds $= Q$

The test for this section is forty-one checks from 50 m.p.h. to 30 m.p.h. with a thirty-six seconds interval between the start of each check. Deceleration to be 30 per cent of g deceleration with every sixth check at 50 per cent of g.

Hill section :

The total energy dissipated by a vehicle weighing 2958 lb is $10 \cdot 4 \times 10^6$ ft lb (Fig. 12).

Therefore vehicle speed at brake application

$= \left(900 + \frac{10 \cdot 4 \times 10^6}{2 \cdot 075 \times 2958}\right)^{\frac{1}{2}}$
$= (900 + 1700)^{\frac{1}{2}}$
$= (2600)^{\frac{1}{2}}$
$= 51$ m.p.h.
$= v_1$

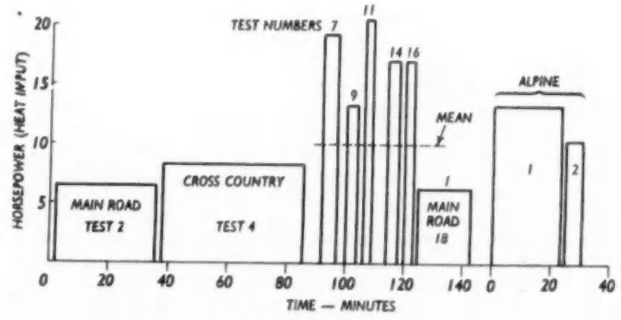


Fig. 14—Mean energy for each road section

DISCUSSION

The discussion was opened by Mr. A. G. Booth, late of Humber, Ltd., who said that the paper was timely and important in content. The procedure was simpler than it looked and yielded considerable information. He agreed with the need for a standard test to prevent inadequate or uneconomical brake specifications.

The proposals were not to be confused with regulations which laid down a minimum braking requirement procedure, but were complementary to them, for example, the Economic Commission for Europe (E.C.E.). He had studied this against the author's test and concluded that the latter covered the E.C.E. requirements for the vehicles discussed.

He reviewed the various alternative methods of heat input and asked if the MCH test bore any relation to dynamometer programmes. The paper said the Alpine test should be carried out after the MCH "if necessary." It seemed to him that it was obligatory also.

He concluded by asking the author's view on the more severe problem of commercial vehicle testing and asked how they rated the Motor Industry Research Association Proving Ground at Nuneaton for both types of vehicle.

Mr. W. Munson spoke on behalf of Mr. Page of the Ford Motor Company, Ltd. They thought that a far more comprehensive programme, including a fade test as well as their General Running Test as they called it, was necessary, and were surprised to see that the authors advocated discontinuance of the former. They also felt that decelerations of up to 28ft per second squared were necessary to ensure braking stability.

Mr. H. Hodkinson of the Brake Division of the Dunlop Rubber Company, Ltd., asked how the MCH procedure compared with current fade tests, how they concluded that it represented true operating conditions, and how they had chosen the order ? He said that on the brakes with which he was familiar fade did not present a problem and that 90 per cent of the complaints that did arise were due the quality of low speed low energy check braking. He did not see why the vehicle maximum speed determined the brake release speed, which he thought would be governed by road conditions and road holding. Finally he asked how the authors compared their procedure with a series of check tests made throughout the brake life.

Mr. F. G. Parnell of the Automotive Products Company, Ltd., agreed that a complete quantitative analysis of brake performance was necessary under widely varying conditions, the worst of which determined the brake size requirement. He found the MCH procedure complicated and suggested the plot of average energy against the duration of each test in Fig. 14.

This diagram illustrates the relative mean

energy for each road section for the typical car considered in the paper. The Alpine test gives the highest energy test input at 285ft lb/cwt./sec. which agreed very closely with his estimate of 275ft lb/cwt./sec. for the retarders for heavy vehicles insisted on by the French Authorities, which had to be capable of holding 40km.p.h. down an 8 per cent gradient.

Mr. Parnell summarised his contribution by saying that 300ft lb/cwt/sec. continuous input covered all conditions, and that any test demanding more than this should be examined. If Alpine conditions were not required, brakes could be comparatively rated by the factor :

$$\text{Brake Area} = \text{Constant} \sqrt{\frac{\text{Engine horse power}}{\text{Vehicle weight}}}$$

Mr. Mackenzie, speaking also for Mr. T. P. Newcomb of Ferodo, Ltd., said that they strongly supported the logical approach to brake usage in the paper, although they did disagree with some detail points in the analysis. They thought that the use of maximum engine horse-power as a factor for determining total energy dissipation (Fig. 5) was not justified as it was only true if the style of driving promoted the worst from the car. They thought that horse-power per unit weight would give a truer criterion than maximum speed. They went on to criticise the treatment of the vehicle as a whole rather than an analysis of the energy absorbed by the brakes. They supported the contention that the main factor in the Alpine tests was weight, but were not sure if it had been properly used. In third gear 0·1*g* equivalent retardation might be absorbed by losses, and if brake application produced a total of 0·2*g*, then 50 per cent of the total energy reached the brakes. If on flat road test the retardation was increased to 0·4*g*, the brakes then received 75 per cent of the total. In this matter there would be differences from car to car. Summarising, they thought the two extremes of Alpine and flat road energy input were controlled by the factors of weight and horse-power per unit weight respectively, and that other conditions represented a gradation between these two. They thought that the test might be simplified on the lines demonstrated by Mr. Parnell and confirmed that there was no relationship between a dynamometer schedule and road test.

Mr. Anthony Powis Bale commented briefly on the excellent choice of the Grossglockner for the basis of analysis.

Mr. T. E. Hodgson, of the British Belting and Asbestos Company, Ltd., confirmed the need for this work and commented on the control of brake bedding and ambient conditions, which he thought were vital to the repeatability of results. In this respect he also queried the use of engine braking during test and asked if the MCH test had been compared with the current fade tests to see whether they gave comparable indications of the performance of any particular lining.

Mr. H. D. Fawell of the Ministry of Transport pointed out that the papers had the main purpose of enabling manufacturers to establish brake performance and to carry out controlled comparisons, and he commented on the need to establish standards of acceptance. In this respect he referred to the E.C.E. test which laid down both energy input and acceptance requirements. Mr. Dawtry also commented on the E.C.E. regulations at this stage and suggested that the authors seriously consider these requirements and also the case of the commercial vehicle.

Mr. J. A. Channer, of Humber, Ltd., was the final contributor. He stated his intention to carry out the MCH and Alpine tests after which he would be in a better position to comment on their practical value. He outlined the Humber fade and simulated mountain procedures which were both based on theory, the latter of which gave good agreement with later results in the French Alps. He commented that these tests were severer than the author's, but they did not necessarily expect the brakes to be serviceable afterwards. The mountain test had been aimed at securing safety from sudden failure rather than fade performance. Fade did not occur to any degree on servo-operated disc brakes, with the result that these excellent brakes would work to dangerous temperatures without the usual warning of performance deterioration. In this respect the good performance of the disc brake did not absolve the driver from the wise use of gears during mountain pass descents. He commented also that brake fluids were hygroscopic and suffered from a dangerous drop in vaporisation temperature after a period of service in humid atmospheres.

Mr. D. F. Woor replied on behalf of the authors. In answer to Mr. Booth he said that a standard test was necessary, particularly for a brake supplier who was dealing with the whole industry. Any aerodrome was a suitable site and the Proving Ground at M.I.R.A. was very satisfactory although it was becoming rather congested. Drivers had been able to cope with the procedure fairly easily, particularly if accompanied by an experienced observer. By saying that the Alpine test should be carried out "if necessary," they did not mean that it was not obligatory, but merely that it would be a waste of time if the car had already failed the MCH part of the test. They had not complicated the paper with temperature measurements which were irrelevant, but agreement between road and test had been good. It was a fact that manufacturers' fade tests varied by three to one, and also that some were too severe to be produced on the road. The dynamometer was used primarily for fundamental testing and bore no relation to road tests.

Commercial vehicles presented a different and more severe problem, but needed a test procedure just as much. There was a wide range of vehicles and the Passenger Service Vehicle seemed a good starting point for further investigation. Commercial vehicles had insufficient power to simulate hill and mountain tests on the flat, and energy input by towing was being considered, but the horse-power requirement for the towing vehicle was enormous to cover the worst cases.

In reply to Mr. Munson, he was very interested to hear that Ford had found a similar approach necessary. He would ask Mr. Munson if 28ft per second squared decelerations were really necessary, as they had found nothing over 0·7*g* (22·5ft per second squared) had occurred throughout the whole programme, and then only in emergency. Such a stop would throw all the passengers out of their seats ; he felt that in tests of this sort one should keep to working conditions.

To Mr. Hodkinson he said that their test procedure was based on the upper limit of brake usage under the most arduous conditions compatible with safety. It was founded on actual road test and must be true for this upper limit. The order of testing was taken in increasing severity at random and seemed reasonable. He agreed that disc brakes were very fade resistant. On the question of brake release speeds, Mr. Woor said that they did vary with vehicle maximum speed, though for the moment he could not see why. [In later discussion with the authors, the answer to this became clear, and was due to the fact that average speeds were being considered. For fast cars some retardations were from 100 m.p.h. to 80 m.p.h. for traffic and brakes were even applied up hill to slow down to negotiate blind crests, &c.—ED., The E.]

Mr. Woor thought Mr. Parnell's slide was very good, and wished they had included it in the paper. He added that the Alpine test was absolutely necessary, and agreed with Mr. Parnell that any test beyond this severity should be examined.

He could not attempt to answer all Mr. Mackenzie's points without going into them thoroughly. With regard to his comment on Fig. 5, Mr. Woor said that their line passed through three points on the upper limit of performance, and since the paper was prepared they had carried out an additional series of tests on an 85 h.p. car, which filled the gap between 100 h.p. and 75 h.p. The same driver who obtained the highest figure on the 130 h.p. car returned a figure for this new car right on their line. This had been shown on the slide, though it did not appear in the paper.

In reply to Mr. Hodgson he said that in the first paper it was imperative that the car was the limitation, not the brakes. Therefore, amongst other modifications the brakes had been very thoroughly bedded. In the second paper the brakes were under test and normal good bedding was accepted. Attention was also paid to ambient conditions, though they felt it was impractical to try to control these too closely.

Mr. Fawell's contribution centred largely on standards of acceptance. The main aim of the paper had been to discuss brake usage. Mr. Woor said he would like to ask what the standards of acceptance were anyway ? It would be easy to draw maxima and minima lines on the unity curves, and he invited comment. He thought the importance of the minimum pedal effort should not be underestimated as it could be dangerous. The stability of the brake was shown by the change of pedal load during one stop and by the rate of change of pedal load over several stops. Both Mr. Booth and Mr. Fawell had raised the point of coverage of the E.C.E. test and his reply was that the Alpine test would amply do this for the vehicles considered.

Mr. Channer had raised the question of disc brakes which were a serious matter. They were considering the possibility of introducing a waiting period of five to ten minutes between the first and second stages of the Alpine test to allow for heat soak. The subject of water contamination of brake fluid should be looked at separately in more detail.

It was gratifying to hear that Mr. Channer intended to try the procedure, and the authors considered it very good that so many manufacturers had been carrying out tests in the Alps over the last few years.

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Electrical Engineers Exhibition

No. II—(*continued from page* 413, *March* 17, 1961)

The tenth Electrical Engineers Exhibition organised by Electrical Engineers (A.S.E.E.), Ltd., was opened at Earls Court, London, on March 21, *by Mr. F. J. Erroll, the Minister of State, Board of Trade. The exhibition remains open from* 10 *a.m. to* 7 *p.m., to-day and to-morrow. More than* 470 *British electrical manufacturers are participating and some of their exhibits are described below.*

Martindale Electric Company, Ltd.

A SIMPLY operated indicator for testing phase and continuity in electrical circuits is being demonstrated by Martindale Electric Company, Ltd., Westmorland Road, London, N.W.9. The indicator can be used on live circuits (*a*) to prove continuity ; (*b*) to identify the faulty line if continuity is not proved by (*a*) ; (*c*) to ascertain the sequence of phase rotation ; (*d*) to prove correct connection of colour coding ; and (*e*) to identify the phase colours of worn, faded or unmarked leads.

The indication is given on five neon tubes contained in a small moulded plastic case from which three heavily insulated leads protrude (Fig. 9). At the end of each lead

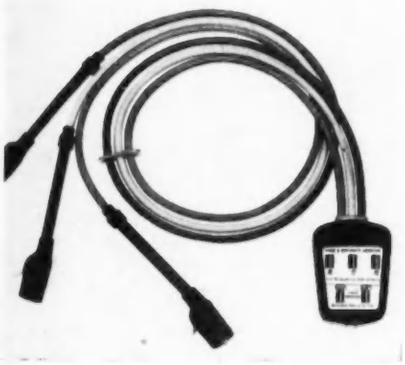


Fig. 9—Phase and continuity indicator—Martindale

is a probe, fitted with a " Neoprene " insulating shroud shielding an insulated crocodile clip for connecting the indicator to the test circuit. Each clip is operated by an insulating trigger which protrudes from through the " Neoprene " shroud as illustrated. Between each clip and the associated flexible lead is an insulated hand-hold section containing a ½A fuse and a limiting resistor to protect the operator in the event of damage to the lead ; the insulating material (like that of the instrument case) is a long-fibre polyester of high dielectric and impact strength. Each lead is heavily insulated with p.v.c.

The indicator instrument contains no moving parts and consists of resistors and capacitors connected to the five neon tubes which, in operation, light up to give unambiguous information about the circuit under test. The top row of three neon tubes are concerned with indication of phase and continuity ; the lower two tubes show phase sequence.

For example, to prove continuity the red, yellow and blue leads of the indicator would be connected to the appropriate coloured phases. On switching on the supply continuity is confirmed if the three top tubes glow. If continuity is not proved the faulty phase will be identified by glowing of the appropriate tube, marked *R*, *Y* or *B*.

The lower two tubes serve to indicate the sequence of phase rotation. Assuming that continuity has been confirmed, the phase sequence at the incoming distribution box, will be indicated by glowing either of the right hand tube marked *RBY* or the left hand tube marked *BYB*. Instructions for interpreting the indications are clearly printed on the instrument face.

The model now in production is designed for three-phase distribution systems of 380V to 440V at 40–60 c/s, but indicators for other system conditions are under development.

Another new product to be seen on this stand is a voltage indicator for use at voltages between 50V and 600V, either direct current or alternating current of any frequencies up to and including those used in aircraft and guided missile control equipment. It consists of a moulded plastics case containing a dial with four neon tubes which light progressively as the voltage rises.

Brookhirst Igranic, Ltd.

Various models of installations incorporating " Bi-Stat " (a static switching system) are being shown by Brookhirst Igranic, Ltd., Elstow Road, Bedford. For example, a model of the Wulpa Lift Car Park shows how twenty cars can be parked in a floor area of only 24ft square, in which the " Bi-Stat " system ensures that any vacant cabins will be immediately available at ground level and that only the appropriate key will unlock each cabin. Another model shows how a synthetic fibre baling press is controlled in its seven sequential operations by a " Bi-Stat " installation which also counts out the predetermined number of bales to be pressed before stitching.

Conventional input devices such as push buttons or limit switches may be used to pass information to a " Bi-Stat " system through potentional dividers. For a reliability, however, to match that of the " Bi-Stat " system, proximity limit switches are used. They are based on a sensed part " A," a sensing part " B " and a receptive sub-unit within the cubicle as part of the " Bi-Stat " system. The principle of operation is electromagnetic and the units employ a ferro-resonant effect to give a snap action " on-off " response.

In application these switches may be mounted in either of two ways depending on circumstances. First part " A " which has no connections is mounted on a moving member ; part " B " is mounted on a fixed member and " reports " to the remote sub-unit. This method employs no contacts and no mechanisms. Alternatively, both " A " and " B " may be contained in a housing which keeps out swarf or turnings. The moving sensed part " A " is then actuated by a snap action push or lever mechanism but still the switch has no contacts.

The proximity contactless limit switch replaces conventional snap action limit switches or is used as an auxiliary contact on motor contactors as a " closed " signal and gives a single output. This output is received on the " Bi-Stat " panel by the sub-unit always associated with the switch as either a " normally absent " or a " normally present " signal which is then fed to subsequent " Bi-Stat " units.

The contactless limit switch comprises a nylon box which contains a stationary " potted " core and a small moving magnet. The whole is usually mounted in a conventional limit switch case, the movement of the magnet being actuated by the limit switch mechanisms. At a predetermined point in the motion of the magnet towards the core (normally absent signal) or away from it (normally present) a ferro-resonant phenomenon sets up (removes) the output of the switch with a snap action effect. Under certain conditions the switch may be sited up to 600ft from the " Bi-Stat " panel.

Proximity limit switches suitable for use in both static and conventional switching systems are exhibited.

Another new product to be seen on this stand is a redesigned " 303 " heavy-duty multi-cell rotary switch for a maximum of 60A on-load multi-circuit switching. These switches are built up of cells (a maximum of six) with moulded partition plates between each cell, the complete assembly being clamped together by two tie rods. Each cell includes a moulded rotor carrying the moving contact rollers (up to four) in peripheral recesses and rotates inside the moulded cylindrical stator. Trapped in slots in the rim of the stator there are fixed contacts (up to four pairs) which are extruded outwards to form terminals. The mouldings are of heat-resistant, anti-tracking, black " Bakelite " ; the clearances and creepage distances exceed those specified in B.S.861 and their effectiveness is enhanced by the use of barrier ribs. Each moving contact element is " dumb-bell " shaped with a contact roller at each end. In the " on " position each contact roller bridges a pair of fixed contact strips in the stator moulding, to give a double break. A spiral compression spring in a recess in the rotor moulding gives even contact pressure on the two rollers in each moving contact. The rollers are of high conductivity silver-plated copper : in the 60A switch the rollers have a $\frac{1}{32}$in thick silver inlay.

There are two alternative kinds of operating mechanism—slow break, quick make for a.c. switching only ; and quick make, quick break for a.c. and d.c. switching. Two current ratings are available—30A and 60A a.c. and d.c., maximum voltage 550V.

A.E.I. Switchgear and Transformer Divisions

The switchgear and transformer divisions of Associated Electrical Industries, Ltd., Trafford Park, Manchester, 17, are sharing Stand G11.

On the switchgear side the most prominent exhibit is one of interest to the electricity supply industry : it consists of one phase of a 275kV, 15,000MVA, 2000A centre-rotating post insulator which is driven by an " MLGO " electro-hydraulic mechanism.

Another equipment exhibited for the first time is an 11kV air-insulated vertically-isolated switch unit (Fig. 10) with integral earthing. This addition to the company's " Q " range of switchgear has epoxy-resin-insulated current and voltage transformers and is designed for an impulse withstand level of 75kV. The single-break oil circuit breaker has bolted epoxy-resin bushings and is designed for ratings up to 250MVA at

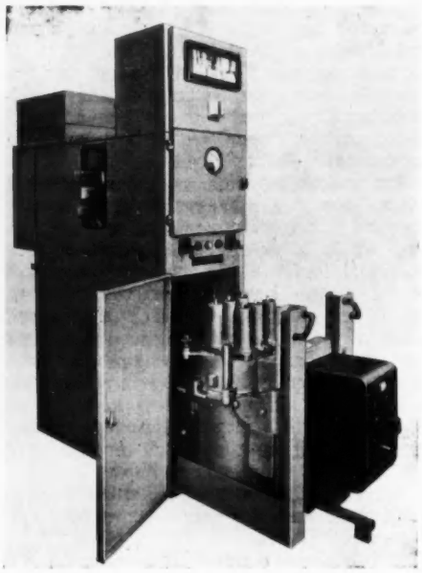


Fig. 10—11kV air-insulated, vertically isolated switch unit (type QA501) with integral earthing—A.E.I.

6·6kV and 350MVA at 11kV.

The transformer division is showing a 300kVA flameproof dry-type underground mining transformer with class "C" insulation. This transformer is combined with a flameproof circuit breaker having internal isolation. Elimination of fire and explosion hazards enables this transformer to be used at the coal face and therefore avoids the volt drop associated with long runs of low-voltage cable between the transformer and the machines it feeds at the coal face. Four sizes of these transformers are available, the ratings being 150, 200, 250 and 300kVA.

One of the new products shown on this stand is a type LA, seventeen position, 33kV, 200A, high-speed, resistor-transition on-load tap changer, which is illustrated (with covers removed to show the mechanism) in Fig. 11. It has a motor-driven operating mechanism with push-button control and is designed for use on transformers up to 12·5MVA.

A.E.I. (Rugby), Ltd.

Various products of the Motor and Control Gear, Electronic Apparatus and Heavy Plant Divisions of Associated Electrical Industries, Ltd., are being shown on Stand K14.

This display includes totally enclosed machines with class "E" insulation and 65 deg. Cent. temperature rise (in accordance with B.S.2613 : 1957) in ratings from ½ h.p. to 200 h.p. Among the exhibits is a newly-developed totally-enclosed type NC motor with closed-air-circuit cooling, typical of a range of medium sized motors with outputs up to 200 h.p. A newly developed brake operated by an A.E.I. electro-hydraulic thrustor is also being shown.

A.E.I. Instrumentation Division

A number of new instruments are to be seen in the display of integrating meters control relays and velometers shown (stand L7) by the Instrumentation Division of A.E.I. Ltd., Trafford Park, Manchester. They include a new type FOS relay for the out-of step protection of synchronous motors. Based on a well-established design it has been developed to enable a standardised relay to be applied to the out-of-step protection of any design of synchronous motor operating at normal power frequencies. The relay is mounted on a schematic diagram showing the connections of the relay circuit with the supply to the synchronous motor.

The Buchholz relay for protecting transformers and detecting incipient faults is being shown in a new form (type 2BFB) embodying magnetically operated metal-to-metal trip and alarm contacts in an assembly designed to withstand railway traction conditions.

A new development in automatic synchronising is being demonstrated in the form of an equipment consisting of three mains units, for voltage, speed and phase matching respectively. The demonstration shows that when matching of these three parameters has been co-related a signal is transmitted to the circuit breakers and the incoming machine is then synchronised with the system.

Ferranti, Ltd.

Display panels containing electronic summation metering equipment and a new Excess Demand Warning System are being shown (Stand C5) by Ferranti, Ltd. This warning system is designed to give improved control over electricity consumption compared with conventional maximum demand warning devices. The system was developed mainly for use in continuously operated plant programmed for maximum production ; its use avoids unnecessary shut downs caused by premature warnings of approaching maximum demand.

The Ferranti a.c. line fault locator is also being shown. A prototype of this device, as described in The Engineer, November 4, 1960, page 761, was demonstrated at Clydesmill Power Station, Cambuslang, nr. Glasgow, towards the end of last year.

This fault locator operates on a pulse reflection principle analogous to radar. A signal for transmission is generated in the locator in the form of 400V peak-to-peak five microsecond pulses, at a mean frequency of 1000 k/cs and spaced at intervals of about five milliseconds. The pulses are coupled to the line and are transmitted along its whole length. All discontinuities on the line represent a change in the transmission characteristics and cause a reflection. These discontinuities may be small, as in the case of towers, or large, as in the case of an arcing fault. The reflected pulses are received by the locator and displayed on a cathode-ray tube for either visual or automatic photographic record.

The locator was specifically developed to detect the position of arcing faults, ice build-up and conductor oscillation on 132kV and 275kV transmission lines, but it can be used for higher or lower voltages. It has been designed for easy and simple operation in manned or unmanned sub-stations and uses the normal station battery d.c. supply. The four units comprising the production model of the locator will fit standard racking and will provide good accessibility for maintenance.

Equipment shown by the electronics department includes low, medium-and high-power silicon rectifiers, rectifier stack assemblies, ceramic-to-metal seals (compression, terminal and lead-through types), industrial valves including stroboscopic tubes and single and repetitive flash tubes. Although the high-voltage cartridge type rectifier stacks, types HS30, HS31 and HS32 with P.I.V. ratings of 5, 7·5 and 10kV respectively, have been exhibited previously, fundamental changes have since been made in their internal construction, giving them a higher mean rectified current rating of 350mA with a much increased surge rating, e.g. 35A for five milliseconds, and a wider field of application.

Epoxy-sealed, low power silicon rectifiers types ZS72, ZS74 and ZS78 are being shown. This range of devices, having a mean current rating of 500mA at 65 deg. Cent. ambient temperature, with a very high surge rating of 35A for five milliseconds, has been introduced to meet the demand for a reliable, small sized, low-priced silicon diode.

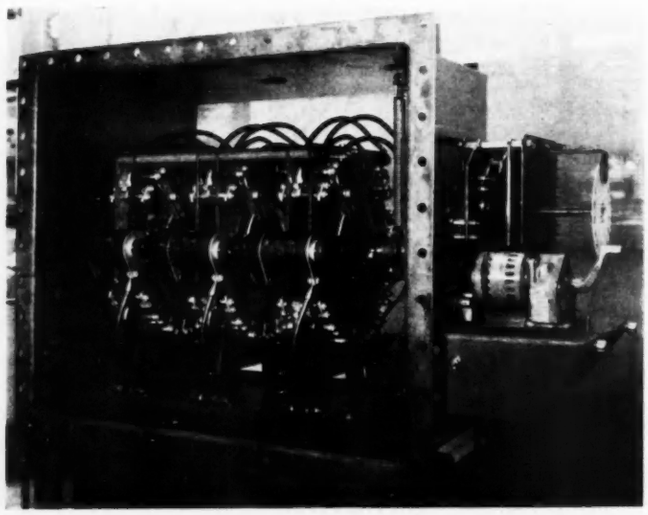


Fig. 11—17-position, 33kV, 200A on-load tap changer with resistor transition—A.E.I.

The General Electric Company, Ltd.

A new 11kV switch fuse ring-main unit is being shown for the first time (stand H12) by The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2. It provides a small and economical equipment for controlling a transformer tapped off a ring main cable in urban and rural areas, and is suitable for transformers up to 1500kVA at 11kV. The unit (Fig. 12) is designed for outdoor or indoor use and consists of two load-breaking fault-making oil-immersed switches in the ring main circuit, together with a similar switch and air-insulated h.r.c. fuses in the tee-off circuit. The oil switches are rated at 400A and the tee-off switch at a maximum of 60A at 11kV, the certified breaking capacity at this voltage being 250MVA. Cable earthing and testing facilities are built into the equipment. Operation of any fuse causes the tee-off switch to trip and isolates all three phases.

For safe replacement of a fuse there is an isolator which disconnects the fuse from the ring circuit and connects the bottom contact of the fuse to earth. Access to the fuses, for

replacement, is obtained from below the tank.

Referring to Fig. 12, the operating handle for the tee-off oil switch is on the left while the handles for the two ring-main oil switches are on the right. Mounted below the tank, the tee-off cable box is on the left, and the ring-main cable boxes are on the right and centre.

The ring main oil switches have three positions, " On," " Off," and " Earth/Test," with independent manual operation. During the initial movement of the handle energy is stored in a spring and this energy is released towards the end of the stroke, to complete the operation independently of the operator and give quick make or break. Each switch has twin blades which are separated by a collar and spring loaded to give firm contact.

The tee-off oil switch has spring assistance to the " Off " and " Earth/Test " position only, and closure to the " On " position is a direct manual operation. A free handle feature gives trip-free operation when closing to the " On " position and the switch can be opened at any time by a " Push to Trip " lever.

Safety from maloperation is provided by a switch interlock in the form of a slotted disc which must be rotated by hand until the orientation of the slot allows the desired operation to be effected while any other movement is positively prevented. The handle cannot be moved directly from " On " to " Earth/Test " or conversely. To prevent unauthorised operation the disc can be padlocked.

Direct manual operation is provided for the tee-off isolator. In isolating the fuses from the ring busbar they are earthed to make safe their removal and replacement. Access to the h.r.c. fuses is given by a hinged lid under the unit, but only when the tee-off circuit is isolated and earthed as explained. When a fuse is being withdrawn it passes through an earthed contact so that the tee-off oil switch need not be in the earth position at this stage. When the lid is open the isolator cannot be closed nor can the tee-off switch be moved to the " On " position.

The company is also showing new additions to its " Mutac Clipper " range of 250V a.c. switch assemblies ; one is an industrial surface type switch with covers and boxes finished in aluminium stove enamel ; and another is a brass decorative switch in satin chrome or B.M.A. (a light bronze finish). In both these new units only three sizes of boxes are needed to give a range of one- to twelve-gang switches.

Two new rotary action switches, rated at 15A and 30A respectively, have been added to the " Hidutac " switch fuses which were introduced at the A.S.E.E. exhibition last year.

Lighting and heating equipments, "Osram" products, and domestic appliances are being shown on Stand V2. Here a novel approach to space heating (the so-called " two-room " heater) can be seen in prototype form. It works by fan-assisted air convection provided by a unit installed in a partition wall. Air is inducted through grilles near the ceiling and is warmed electrically before being discharged into the room through vents in the base of the unit. By operating adjustable vanes the air can be directed into either room or both rooms simultaneously. The heater is a 4·5kW " Nichrome " spiral element protected by two hand-reset thermal cut-outs. Heating can be controlled by an adjustable thermostat, with the element switched to full heat or to 1·5kW for background warming. In warm weather the fan can be used to give air circulation with the heater switched off.

Fig. 12—Type DDFA ring main unit equipment with a fused tee-off circuit—G.E.C.

British Insulated Callender's Cables, Ltd.

Power cable exhibits (stand F10) shown by British Insulated Callender's Cables, Ltd., 21, Bloomsbury Street, London, W.C.1, illustrate some of the interesting contracts which this company is engaged upon. The display includes a sample of the 100kV, d.c., single-core submarine cable which will be laid in May, 1961, on the bed of the English Channel as part of the power link between the national grid systems of Britain and France. The contract, which was placed by the C.E.G.B. jointly with B.I.C.C. and A.E.I., calls for the manufacture and laying of two 15-mile submarine lengths and the two related land cables.

There are also two specimens of 330kV, single-core, oil-filled cable : the 0·85 square inch cable for the Kariba Hydro-Electric scheme and the 0·25 square inch cable for the T2 Power Station of the Snowy Mountains (Australia) Hydro-Electric scheme. Although these cables will be installed on a 330kV system, they are designed to be equally suitable for operation on the projected 400kV system of the C.E.G.B. Included in this display are specimens of the 2·15 square inch, 230kV, single-core, oil-filled cable for the Hydro-Electric Power Commission of Ontario, 230kV and 69kV, single-core, oil-filled cables for service in British Columbia and a 66kV, three-core, oil-filled cable with corrugated seamless aluminium sheath and P.V.C. oversheath for service in China.

Samples of power cables for home contracts include a 132kV, single-core, oil-filled cable for the C.E.G.B. to augment the Kingston-Wimbledon and Chessington power supplies and a 25kV, oil-filled, concentric C.S.A. cable with aluminium conductors supplied to the British Transport Commission for their railway electrification scheme.

A number of new products developed and manufactured by the Accessories Division are on show for the first time. They include two new ranges of cable glands designed for threaded-entry fixing—the " G " range comprising general purpose glands for rubber or plastic non-metal sheathed cables installed indoors or outdoors ; and the " H " range for metal and non-metal sheathed armoured and unarmoured cables in flameproof, watertight and similar installations. Other Accessories Division developments include new types of flameproof and weatherproof 3·3kV, 300A, bolted cable couplers and adaptors meeting revised British and current International Standards and complying with C.E.G.B. recommendations for connections to auxiliary motors in power stations. There are also new sheet steel junction boxes for use with mineral insulated cable multiple rising main systems with " off-peak " loading.

The " Communications " theme of the Exhibition is emphasised by the exhibits of the Telephone Cables Division. Specially screened telephone cables required for replacing trackside telephone wires have been designed and manufactured by B.I.C.C. and are being installed by the Group's contract organisation, B.I.C. Construction Company, Ltd. Some idea of the problems which had to be overcome in providing these trackside telephone cables is shown by a special display.

The main exhibits of the Panelec Heating Division of B.I.C.C. are the rewirable and solid embedded floor warming systems. The former, which was the first rewirable system to be marketed in this country, uses lead sheathed heating cables which can be withdrawn and replaced, if necessary, without disturbance to the floor finish. The solid embedded system meets the demand for a cheaper form of floor warming. The " Panelec " fault monitor, a portable transistorised instrument which gives audible and visual indication of any damage that may be sustained by the cables is recommended for use during the installation of the system.

(To be concluded)

LETTERS AND LITERATURE

Letters to the Editor

MILLIONS TO BE SAVED ?

SIR,—I should like once more to reply to the letter of Mr. J. V. Walker (THE ENGINEER, March 3).

Comparison of road and rail accidents was made by Brigadier Lloyd to illustrate that when related to the population's liability and exposure, road accidents are not so bad as the Press would have us believe. It must surely be conceded that the reserved road network, built on the permanent way, would have an accident rate not higher than on present U.S. turnpikes. It is the conditions after conversion and fully modernised railways such as in France which should be envisaged and given consideration.

Let us look at the subsidies which Mr. Walker considers road users enjoy. Traffic wardens and police (do we " enjoy " them I wonder ?), traffic signals, parking spaces and hospitals. The large traffic police force is required mainly because of the Government's thousands of regulations which are designed to side track the public from the plain fact that only a feeble amount of practical road work is being done. The hospitals were with our society before the automobile and in any case have to deal with more accidents from the home than the road. I cannot see why Mr. Walker considers the above services are subsidies to the road user in particular. These services are provided by the taxpayer for the benefit of the entire population. Motor taxation contributes £600 million a year and only one fifth goes to the upkeep and extention of the road system. I think that Mr. Walker is in danger of being tarred and feathered when he says, " we may find that road transport pays nothing like enough taxation."

If the railways were allowed to compete on equal terms with road transport, they would have to pay some £120 million in fuel tax and five times their £90,000,000 permanent way upkeep bill. This total of £570 million a year is, in fact, a fantastic protection of the British Railway system from the economics of road transport. To allow the railways to compete on equal terms would be the quickest possible way to their eclipse and conversion to roads would follow naturally.

In comparing his local bus and rail service, Mr. Walker ignores the point that the buses are running on an antiquated roadway which is grossly overcrowded and has neither the reserved nature nor the superb engineering qualities of the permanent way.

I can never understand why the railway enthusiasts in proclaiming the virtues of rail travel fail to realise that they all stem from the permanent way itself, not the train. The decline of railways the world over, whether fully modernised or not, can only be due to their inherent inflexibility and lack of convenience.

At the cost of some £20,000 million it would be possible to build roads overhead and to the same width as the present rail beds. Were this done, can anyone sincerely believe that trains would continue to run ?

I consider that the comparatively slow decline of the railways is only due to the increasing congestion of road vehicles. These vehicles would come to a halt in an hour, but for their flexibility.

When one realises that the £160 million electrification scheme on the London Midland main line would provide sufficient capital to turn it into a motorway, I can only pray that the Government can find the guts and determination to try this as a pilot scheme.

In conclusion, since not one of the Railway Conversion League's critics has suggested a solution to the road traffic problem even apart from the railways, I suggest that whatever the public may think at the moment, the conversion of the railways into roads is inevitable.

J. E. HUSON

Worthing,
Sussex,
March 5, 1961.

SIR,—I see that the Inner Circle is also " on the list " so far as Brigadier Lloyd is concerned, and that he promises us transit speeds of 35 m.p.h. after conversion.

I assume from this that I could confidently expect to travel the 2½ miles from King's Cross to Paddington in the evening rush hour in about four-and-a-half minutes and that the thousands of travellers who use the line at that time could expect similar quick journeys.

Now from 5.30 p.m. onwards the headway between successive trains at present is about two minutes—sometimes less. Taking an average train of seven coaches, forty seats per coach, and as many more passengers standing this means that an average of 550 to 600 passengers have to be conveyed every two minutes past any one point. Double decker buses would be out of the question, and with forty-seaters there would have to be twice as many buses as there are railway coaches now passing—that is fourteen every two minutes. The headway is thus roughly one every eight seconds.

Now as to operation : the station stops in the rush hour could could not be less than fifteen seconds each, so that in the journey of four and a half minutes from King's Cross to Paddington, an aggregate of one minute would be spent standing at the four intermediate stations. This leaves a running average of 43 m.p.h. to be maintained in station-to-station runs of about ¼ mile, and this would mean maximum speeds of over 60 m.p.h. The acceleration from rest to this maximum would have to take place in thirty-five seconds at the most, followed by a rapid braking, and this performance would have to be achieved by a succession of heavily loaded buses running at a headway of eight seconds, and for the most part in tunnel.

Some years ago the well-known monthly feature article in *The Railway Magazine* was pilloried in *Punch* in an amusing skit entitled " British Motorbus Practice and Performance." One feels that " Practice and Performance " on the Inner Circle in the " Lloyd Age " would be worth going many miles to see !

O. S. NOCK

Bath,
March 9, 1961.

SIR,—Cannot some psychologist come to the rescue and " blow the gaff " on this controversy ? Plainly, the " Railway Conversionists " are men with a frustration ; the frustration of driving on our overworked roads whilst seeing the apparently clear " splendid highways " of the rails alongside. In such case, all factual arguments of engineering, economic and safety considerations are unavailing. An obsession—right or wrong—gives to its possessors a wonderful facility to reject, ignore or invert disagreeable facts. Your readers would do well to study the correspondence with this in mind.

H. ROY GUENIN, B.Sc., A.M.I.C.E.

Haxby,
York,
March 10, 1961.

SIR,—May I reply and then retire from the fray ?

Mr. A. I. Watkinson makes the point that M1 is only 75 miles long, but the A45 continues to the outskirts of Birmingham as a first-class dual carriageway, and extension at the London end is planned. The 1 in 330 ruling gradient of the London and Birmingham railway was designed for the 12 ton four-wheeled Bury locomotives of the day, and the 1 in 70 of Camden Bank necessitated cable haulage. Is the additional fuel consumption of modern road vehicles on a few miles of 1 in 30 a sufficient reason in itself for the revolution which is proposed ?

If Mr. Gordon England did not mean private motorists when he spoke of the public's preference for a means of transport which gave freedom of choice I cannot think what he intended to convey by the phrase. To eliminate one existing system of transport which is used by millions can hardly be claimed to add to freedom of choice.

As to my second " Aunt Sally " I note that he is himself a motorist who for the past fifteen years has voluntarily chosen travel by train to London in preference to travel by car—which he says he prefers. I gather—but here again I am not sure if I have understood him aright—that his reason is the introduction of parking meters, but they are so recent that they could not have affected his choice during all this period. Why, incidentally, does he regard them as " a preposterous imposition " any more than the imposition of rates on the equivalent of parking space for public service road or rail vehicles, which is included in the fares he pays ?

He makes the second point that he has given an intensive study to traffic problems for the past seven years. It so happens that this covers the period of the early stages of railway modernisation by way of diesel trains and the extension of electrification, which have resulted in such striking increases in passenger traffic, yet I suspect that his views on this subject were formed seven years ago since he still considers railways to be effete.

As to my third "Aunt Sally" perhaps I was a little unkind to suggest that his was a voice crying in the wilderness—but in all seriousness his present letter does lend colour to the suggestion. To him the arguments for universal conversion are so manifest and overpowering, and there is such an absence of a "well reasoned case in rebuttal" of them that he simply cannot understand why the modernisation programme is in hand at all. By what stretch of imagination does he infer that Mr. Peter Thorneycroft was referring to this proposal, and if so was not, what is the relevance of the quotation? Mr. Thorneycroft is now a member of the Government which, after studying exhaustive independent reports, has decided to proceed with the Euston to Crewe electrification. I happen to know Mr. Thorneycroft and I can assure Mr. Gordon England (if, indeed, he is really in doubt) that in suggesting in effect that he would remain in a Government whose policy he does not support, he has picked on the wrong man. Be it noted that the Government has made it very clear that this decision forms no precedent for the future. They are following the fundamental engineers' method of studying each case on its merits—as I was trying to do in my reply to Brigadier Lloyd in the same issue.

Does Mr. England say that all our Continental neighbours are wrong in developing motor roads and railway electrification side by side—and if so, does he really contend that my metaphor was so very far from the truth? I suggest that Mr. Gordon England and his friends are comparing a system of roadways and outsize coaches, which so far are only proposals, with railways of the Stephenson age, not with the railways of the second half of the twentieth century.

May I conclude by saying that although our approach to this problem is clearly different, I shall always be grateful to him for producing those marvellous little Austin Sevens in the 1920s?

J. R. HARDING

Sutton Coldfield,
Warwickshire,
March 3, 1961.

INDUSTRY OR LANDSCAPE

SIR,—In your courageous article "Industry or Landscape," November 25, 1960, there are notable omissions and misconceptions. The argument based on "standard of living" is incomplete, since the leisure brought thereby, is, by many people, spent in the country—if they can find any. On our crowded island, this facility should, if possible, be protected.

It has never been apparent to me, from proposed and existing industrial development, that "big-business" would let aesthetics stand in its way—not if it costs money. A tour round the industrial north with its miles of decrepit mills, stinking rivers and cancerous sprawl of nondescript buildings, make your epithets sound a bit hollow.

No wonder the phrase "a middle road" is treated with suspicion by people who love the countryside. They will think of the fate of Glen Nevis (shall we sing: "By Loch Tummel and Loch Rannoch and the power station I will go"); the radioactive valleys of North Wales; they may even digress to remember the killer insecticides and sprays which slay birds, animals, butterflies indiscriminately.

Your article has the tone of complacency: for lovers of the countryside, there is no room for complacency.

A. P. ANDERSON, B.Sc.(Eng.), Ph.D.

Stockport,
March 15, 1961.

DISCOUNT ON BOOKS

SIR,—We note in your issue of March 10, in the review of *Principles and Practice of Aircraft Electrical Engineering*, by Zeffert, that in the last paragraph your reviewer comments, "Or let it be done through a local book-seller who is prepared to make it attractive to the firm's management by dividing the discount." We must advise you that the practice of allowing discount to firms, on net books, is strictly forbidden by the Net Book Agreement in conjunction with the Publishers and Booksellers Associations.

A. J. STOYEL,

Manager, Technical Books
Dillon's University Bookshop, Ltd.,
1, Malet Street, London, W.C.1,
March 10, 1961.

Book Reviews

Off-The-Road Locomotion: Research and Development in Terramechanics. By M. G. BEKKER. The University of Michigan Press, Ann Arbor, Michigan, U.S.A. Price $10·00.

THAT the study of soil/vehicle relationships might allow breaches to be made through the severe and onerous limitations of the performance of off-the-road vehicles was for long a belief limited to a very few, so much so that, despite the human race being very largely earth-borne, the preface is able to name all the universities providing graduate courses in land locomotion—four in the United States of America, one in Germany, and one in England. But the growth of interest in such a topic is very likely to grow exponentially, and a volume such as this, describing not only the theory but also its applications and potentialities, may well have an influence proportionate to its price.

The treatment commences by examining the performances achieved by various methods of locomotion, ranging up from the way of a snake upon a rock, and comparing them with the fundamental limits set by the properties of the available materials: crosscountry vehicles line up with the running and sliding animals rather than with the remainder of wheeled vehicles, so that the author deduces that a reduction in motion resistance is the one promising way of improving their performance. There follows a closer study of vehicles, in which the principal conclusion is that the free-ranging surface vehicle has stabilised about proportions which do not give particularly high mobility and result in a ground pressure equal to that of a building at the not extreme weight of about 75 tons. One reason suggested for the absence of functional shapes among land vehicles—the author has had to abandon the belief embodied in his 1956 publication "Theory of Land Locomotion: The Mechanics of Vehicle Mobility" that the high-performance passenger vehicle was, in general, streamlined—is the use of major components, particularly engines, developed without the special needs of vehicles being considered paramount.

The next two chapters discuss the physical properties of the ground needed to determine the behaviour of a vehicle by the methods of soil mechanics, and the geometrical properties that evoke limitations set, subject to modification by the vehicle suspension, by the strength of materials and the tolerance of the human being. Any mechanically-inclined engineer who hopes to skip these chapters will suffer a rude awakening in the next, on "The Idea of 'Flotation' and Vehicle Performance," where examples are adduced to show that on dry sand the pressure that a track will support without sinkage varies directly as the track width, whereas the amount of sinkage for a given pressure increases with the track width—his difficulties, it must be admitted, may be due partly to faulty substitution in the equations in the first example. From here on there is likely to be little quarrel with the tenet that an intuitive approach is inadequate!

The following two chapters analyse the thrust and drag exercised by the soil, the former by use of a generalised form of Coulomb's equation which enables the distribution of thrust along the length of the contact patch to be derived, leading to the conclusion that low slip is, in general, a property of long, narrow contact areas. The statement that "it has often been claimed that a low pressure pneumatic tire can perform as well as a track" comes as a marked retreat from "tracked trailers do not appear to have any reason for existence" in the earlier volume, and indeed it appears that the inflation pressures needed for the tyres to behave as other than solid may be forbiddingly low—single figures in lb per square inch—while the form of tyre construction that results, an exaggeratedly low profile design, is accused of high bull-dozing resistance. From studying thrust and drag one comes naturally to drawbar pull, often the design criterion of the vehicle, and it is shown that no useful measurements or predictions can be made without exact knowledge of the properties of the soil, although general trends, such as the need for more and more elongated contact areas as the soil becomes weaker, are indicated.

In Chapter X the methods developed in the earlier part of the book are used to assess the potentialities of existing vehicles, and it is shown that relatively little improvement can be expected, due to the quite insistent need to be able to steer the vehicle, which limits the track length, and to the observation that even 10ft diameter tyres of great costliness have not met the requirements of mobility. It is not, of course, suggested that all existing vehicles are equally inadequate, and it is hinted that the British practice of using small, *spoked* undriven wheels as a weight-saving measure needs re-examination. The recurrence of the demand for diameter is the most obvious sign of the breach between the approach of the author and that extant in this country.

The author then attacks the plasticity problem for a single isolated track plate (cleat) under vertical and tractive loads. Not

LETTERS AND LITERATURE *(continued)*

surprisingly, it transpires that the shear failure disturbs the soil for a significant distance in front of (relative to the ground) or behind (relative to the vehicle) the cleat. Hence it is deduced that further cleats lose in effectiveness if they are not placed beyond the disturbed soil. The author therefore proposes that a "spaced link" track, reminiscent of the overall chains of a six-wheeled vehicle, will affect the same amount of soil with a considerable economy in expensive and heavily-worked metal for the tracks. It would seem that the most empirically-inclined designer should have been able to reach the same conclusion, had he stopped to ask whether the present form of the track was optimal! However, it transpires, both in theory and in practice, that a spaced link track is superior—i.e. more traction at slips less than 100 per cent—which results from the fact that the increased pressure on the reduced area of the cleats results in the shear failure extending deeper and further beyond the sides of the track. Nor is this all: the increased sinkage results in better performance in the commonly occurring instance of viscous mud lying above a hard base, and the spaced link track proves to be a better propeller in mud and water, since the bull-dozing resistance is greatly reduced. Thus the new track offers the greatest improvement in the very circumstances where conventional tracks experience most difficulty. This first fruit of the analytical approach to terramechanics has so far been exploited only in one vehicle, the "Groundhog," which demonstrated the extraordinarily high drawbar pull of 180 per cent of its own weight.

Having demonstrated one advance attributable to the application of theory, the author seeks fresh fields to conquer, and proposes to resolve the conflict over whether to use one or two wheels at each end of an axle, so evidently undecided on the immediate post-war 2½ ton trucks and the "Hippo" of the 1939-45 war, by using two tyres, one within the other, on one wheel: one misses any reference to the success achieved in off-the-road applications by "X" tyres in Europe, since the experimental corroboration is confined to tank (bin) testing of 20in tyres carrying only 27lbs (*sic*). More radical designs to exploit the potentialities of the track are then sketched, such as the "skid suspension" intended to overcome the long-standing objection to the balloon tyre that at any instant most of it is doing nothing: apparently to emphasise the confidence of the author in their performance, grotesquely difficult mechanical designs are indicated, with such comments on the "Problems of an engineering nature" as "Tests indicate the feasibility *of the idea*" (our italics).

The next chapter reverts to first principles to define mobility in a sense lending itself to quantitative measurement, after which the problem of evaluating "soil trafficability" is discussed. This latter is one of the most tantalising chapters. Time and again the author has demonstrated the prevalence of quite irrational relationships between such fundamental parameters as weight and wheel proportions, or ground pressure and track aspect ratio, a phenomenon which can readily be explained if one postulates that testing techniques capable of distinguishing good designs from bad have been lacking. By deriving a thrust *v.* weight relationship for an ideal vehicle in a selected soil the author obtains a graphic indication of how any measured vehicle performance compares with what the soil can support, which "is a logical index of the efficiency of design." The implications of this are so enthralling that it is perhaps appropriate that the chapter ends with a comma!

The final chapter discusses the organisation of research, currently hag-ridden by this ever-recurrent difficulty of demonstrating that a desired improvement has in fact been achieved. However, the underlying philosophy is that the design of the parts should be subordinated to the concept of the whole vehicle, a dogma that is rejected in this country, so that the proposals for learning and teaching will appear as radical as those for optimised vehicles. It is noteworthy, however, that Col. Bekker has recently become head of the Land Mobility Laboratory of General Motors (Defence Systems Division), so his outlook cannot be generally regarded as heretical.

It has perhaps already appeared that some details of the preparation of the text have been hurried, and it must be observed that the subject will appear to any reader commencing with this book to have been unevenly covered. Particularly one wishes for at least a dismissal of dimensional analysis: ubiquitous are two constants of soil deformation, k_c and k_ϕ, abstracted from the author's original work with no deeper explanation than that their dimensions are

$$\frac{\text{lb}}{\text{in}^{n+1}} \quad \text{and} \quad \frac{\text{lb}}{\text{in}^{n+2}}$$

where n is the power of sinkage in the equation of soil deformation in compression, while there is quoted an equation

$$p = \frac{bsl^2}{2h}$$

where p is pressure, s stress, and b, l, and h are lengths. Nevertheless, there can be few who will complete reading this volume without hoping for yet a third recording the achievements in practice of the still-young study of soil/vehicle systems.

Physical and Engineering Properties of Cast Iron. By HAROLD T. ANGUS, Ph.D., M.Sc. The British Cast Iron Research Association, Alvechurch, Birmingham. Price 52s. 6d.

DESIGN staffs of engineering concerns, all of whom use cast iron in one form or other in their machines or constructions, will undoubtedly appreciate the real value of this new data book. They have long needed such a volume, specially written for engineers and designers, because cast iron is much more complex in structure and behaviour, and always less ductile, than the mild steels with which the bulk of their work is done. The author has been noted as a keen student of his subject and he has taken pains to read foreign works on cast iron during his long service with the British Cast Iron Research Association, of which he is now the Deputy Director. He has gained unusually wide experience of foundry work with cast iron through his liaison work between the association's laboratories and head offices and the numerous foundries helped by the B.C.I.R.A. While so employed he built up a private collection of data that he had found necessary at some time or another in dealing with problems submitted to the Development Department of the B.C.I.R.A. In assembling, correcting and checking that collection to form this book he was helped by the other two departments of the association, "Research," under Mr. H. Morrogh, and "Information," under Mr. G. R. Woodward. The data have been culled from far and wide, almost every industrial country in the world having contributed notably to one or other section.

Instead of attempting to provide a detailed treatment of all subjects dealt with, the author has summarised the latest research work and given the appropriate references; he notes in particular the papers by Morrogh on the metallurgy and metallography, and by Collaud and Gilbert on the mechanical properties of cast iron. With its 528 pages this is quite a big book and the essential index, of twenty-eight pages, has been very clearly printed with prominent headings followed by sub-headings and page references. How helpful this index may be to the man searching for data may be shown by noting that under the prominent heading of, for example, "Malleable Cast Iron, Blackheart" one finds thirty-seven lines of sub-headings and eighty-three numbers of the pages to which one is guided alphabetically all the way from "brittle fracture" to "yield point."

During the past thirty years many modifications of cast iron, due to alloying or heat-treatment, have become well established in industry and many trade names for special cast irons have almost become accepted as standardised descriptions. Design offices will therefore find this index, written by an unbiased authority, very helpful in leading them to a definition and much more, concerning, for example: Duriron, Meehanite, Minovar, Nicrosilal, Ni-hard, Ni-resist, Ni-tensyl, Nodular cast iron, Nomag, Perlit, Silal, Silicon irons, and of course our older friends Grey cast iron, White irons, and the Blackheart, Pearlitic, and Whiteheart varieties of malleable cast iron. Similarly one may find, neatly assembled in the appendix, summarised data on Grey cast iron, White iron, and Malleable iron.

The main body of the book is divided into nine parts, the first of which deals briefly with the constitution and structure of cast iron. Folding pages are here included which reproduce the A.S.T.M. sizes of flake graphite, from size 1 (4in or more) to size 8 ($\frac{1}{16}$in or less) and types A to E. In future editions these two folding pages should be printed Fig. 3 and Fig. 4 to help the reader to link them up with the text. In this part of the book one may admire Figs. 7 to 28, which reproduce photomicrographs at 60, 100, 150, and 600 diameters magnification, for they are of that excellence for which the B.C.I.R.A. metallography is justly renowned. The 156 pages of the next part of the book form almost a third of it in describing the mechanical, physical and electrical properties of cast iron; Part 3 covers the general properties of commercial cast irons. It is in this part that one may find authoritative comments on the composition and structure of grey cast irons, low alloy cast irons, malleable cast iron, nodular cast iron, austenitic cast iron, non-magnetic cast irons, nicrosilal, acicular cast iron, white cast iron, martensitic cast iron; to mention only the more important headings.

Thereafter the author writes about the special properties affecting the service rendered by these materials, such as heat-resistance, and mechanical properties at high temperatures, low-temperature pro-

perties, wear resistance and corrosion resistance, protective surface coatings and machinability.

Part 5 considers the heat-treatment of cast iron, surface hardening and welding ; it is followed by an important section on internal casting stresses, camber in castings, contraction allowances and dimensional tolerances. The last three parts of the book deal with quite specialised aspects of design, such as components with high local loadings, gears, cams and tappets, flywheels and die blocks. The mere mention of these examples underlines how extraordinarily important the numerous varieties of cast iron have become. It is safe to add, therefore, that this book fills a real need; it will be welcomed by metallurgists and it should be regarded as an important source of data.

Fuel Cells. Edited by G. J. YOUNG. Reinhold Publishing Corporation, New York. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 46s.

THIS book is based on a symposium which was organised by the Gas and Fuel Chemistry Division of the American Chemical Society and was held in September, 1959. It contains the papers presented at the symposium together with a brief summary of the panel discussion that followed. Among the contributions are Bacon's paper on the high-pressure hydrogen-oxygen fuel cell and a paper by Chambers and Tantram on carbonaceous fuel cells. Other chapters deal with the hydrogen-oxygen (air) fuel cell with carbon electrodes, by Kordesch ; the catalysis of fuel-cell electrode reactions, by Young and Rozelle ; the electrode kinetics of low-temperature hydrogen-oxygen fuel cells, by Austin ; high-temperature fuel cells, by Broers and Ketelaar ; and molten alkali carbonate cells with gas diffusion electrodes, by Douglas.

The summary of the panel discussion at the end of the book probably suffers from the fact that this part of the proceedings of the symposium has been compressed into three pages. Its value as a means of assessing the practical prospects of the fuel cell is correspondingly reduced. The wry comment is made that, if a sizeable fraction of the investment that had gone into atomic energy development were put into fuel cells the prospects for wide application would be fairly good. However, it is suggested that small mobile power sources will probably be available in the near future but no conclusion is offered as to whether they are likely to be commercially competitive. It is thought that fuel cells may offer advantages over conventional batteries in the field of traction, in Germany, for example, where (it is stated) battery-driven railcars are competitive with diesel electrics.

Statik der Pfahlwerke. By FRIEDRICH SCHIEL. Berlin–Göttingen–Heidelberg : Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3. Price DM.28.50.

BASING itself on recent work by Asplund and others, *Statics of Pile Constructions* presents a generalised theory of design of piled foundations which at the same time can readily be simplified to accommodate special cases. Although some of the results obtained will be found to be of interest in other branches of civil engineering design, these matters are not pursued as leading beyond the scope of the book. Neither is the soil mechanical aspect (floating foundations) about which there exists a wealth of literature which is still growing rapidly. While a clear presentation of the results is only possible by the use of matrix notation, matrices are not employed in the actual mathematical development which throughout confines itself to elementary methods. A final chapter deals with problems which confront the practical designer.

The Farm Shop. By T. J. WAKEMAN and V. L. MCCOY. The Macmillan Company, New York. 10, South Audley Street, London, W.1. Price 39s. 3d.

A FULLY-MECHANISED farm is frequently likened to a factory. This alone emphasises the importance of maintaining all kinds of equipment in good condition. Although in this country there are still numerous farms of relatively small acreages it must not be overlooked that there are many large farms which need an extensive range and quantity of machines and implements. Thus, the equipment of the farm workshop is of importance. This book, based on experience of American farm workshop practice, is a detailed treatise on how to organise and run a workshop on the farm. Its scope is wide, for it includes such matters as plumbing, glazing, carpentry and masonry, in addition to the more obvious techniques such as welding and metal working. The text throughout is easily understandable and the numerous sketches and half-tone illustrations indicating " how to do it " are admirable. Much of the information contained in the book is, we should say, pretty well known throughout British mechanised farming to-day, but the authors have performed a useful service by bringing it together.

Fast Reactor Cross Sections. By S. YIFTAH, D. OKRENT and P. A. MOLDAUER. Pergamon Press, Ltd., Headington Hill Hall, Oxford. Price 35s.

THE problems associated with the design of fast reactors are very different from those of thermal reactors. Because of the relatively small cross-sections of the core materials at high neutron energies the heterogeneity problems occurring in thermal reactor design are usually absent in fast reactors ; significant neutron interactions now occur, however, over a wide range of neutron energy instead of being mainly concentrated in a quite narrow energy range. With the use of high speed digital computers the mainly geometrical problems of core design and the problems associated with the slowing down and diffusion of neutrons can be solved by the use of multi-group programmes. The basic problem which remains is to determine the appropriate neutron cross-sections describing the behaviour of the different neutron energy groups.

The purpose of this volume is to construct a self consistent multi-group set (sixteen neutron energy groups) of cross-section data and to explain in great detail how the numbers are derived from basic data so that new information can be readily incorporated as it arises. This part of the work is carried out with great care, full references being given to all sources of information and an analysis being made of possible sources of error. There follows a chapter in which an analysis is made of the areas in which further experimental work is needed. Finally a comparison is made between the predictions of the multi-group data and the results from experimental reactor systems.

This volume will be of great value to those working in the field of fast reactors since it is probably the first really well documented analysis of fast reactor cross-section data free from empirical adjustments. The high price no doubt reflects the fact that the number of possible users is small.

Books of Reference

The Shipping World Year Book and Who's Who, 1961. The Shipping World, Ltd., 127, Cheapside, London, E.C.2. Price 60s.—This edition of the *Year Book* is set out as in previous years in five main parts which provide classified information concerning the various sectors of the maritime industries, and these are more readily and easily found by the introduction of distinctive marker tabs. General information is grouped in Part I, while Part II lists abbreviations used for shipping terms and includes particulars of Who's Who in the shipping world. The statistical section is followed by the classified directories which form the largest section of the book and record details of personnel at all levels of shipowners, shipbuilders, ship-repairers, marine engine builders and licensors, towage and salvage contractors, and port and harbour authorities of the United Kingdom. The directory of shipowners has been greatly expanded and now includes approximately 1800 companies which are listed by country in alphabetical order. This arrangement also applies to the other main directory sections in which, where appropriate, are listed building capacity, repair facilities, type and horsepower range of machinery built, and towage equipment. Part V covers the Government and maritime organisations and includes a directory of shipowners' mutual clubs. The volume is completed by a comprehensive index of firms, against each of which is set a directory code letter.

Electricity Undertakings of the World (*The " Red Book "*), 1960–61. Edited by Norman H. Codling, D.F.H.(Hons.), M.I.E.E. Benn Brothers, Ltd., 154, Fleet Street, London, E.C.4. Price 35s.—In a foreword to this seventieth edition of the " Red Book " the editor comments on the significant technical advances now being made in conventional thermodynamic generating plant ; on the parallel progress in the bulk transmission of electricity ; and on the striking growth in the consumption of electricity, particularly in Europe. This forward-looking preface to the subject provides a useful introduction to the main contents which gives in great detail, technical and statistical information about electricity supply throughout the world. The general arrangement follows that of the previous edition.

Administrative changes in the supply industry in Great Britain reflect the continued trend towards decentralisation and the book records detailed changes in the Midlands, East Midlands, North Eastern and Yorkshire Regions, as well as in the South Western Board, where the number of districts has been reduced, by merging, from nineteen to thirteen. In the section dealing with Commonwealth countries new information is given about electricity supply in Pakistan, Pemba Island (East Africa), the Solomon Islands and Somaliland ; fuller details are given about the new system that is being installed in the Seychelles.

In the section on foreign undertakings there are twelve new entries for Mexico and fresh information is given concerning the systems and voltages in Moscow.

Books Received

Dictionary of Automatic Control. By Robert J. Bibbero. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 45s.

Progress in Nuclear Physics. Vol. 8. Edited by O. R. Frisch, Pergamon Press, Ltd., Headington Hill Hall, Oxford. Price 90s.

Technology Engineering and Safety. Series IV, Vol. 3. By C. M. Nicholls. Pergamon Press, Ltd., Headington Hill Hall, Oxford. Price 105s.

The Hall Effect and Related Phenomena. By E. H. Putley. Butterworths Scientific Publications, 4 and 5, Bell Yard, London, W.C.2. Price 50s.

The Electro-Erosion Machining of Metals. By A. L. Livshits. Butterworths Scientific Publications, 4 and 5, Bell Yard, London, W.C.2. Price 30s.

Mechanized Cutting and Loading of Coal. By R. Shepherd and A. G. Withers. Odhams Press, Ltd., 96, Long Acre, London, W.C.2. Price 50s.

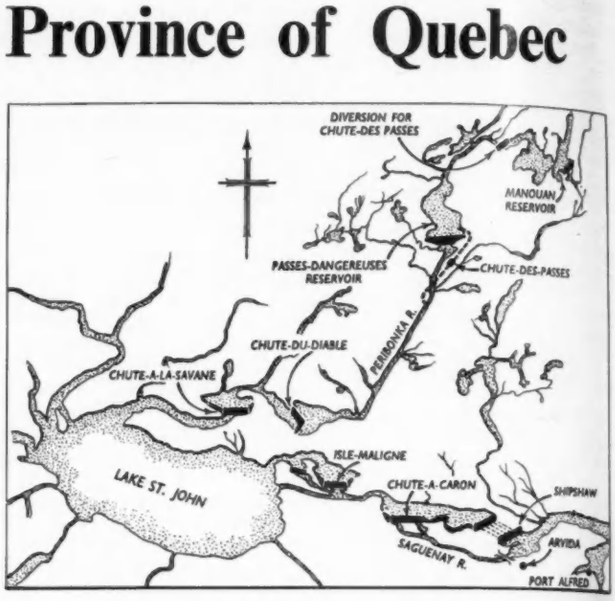
Engineering. The Profession and Elementary Problem Analysis. By H. W. Leach and George C. Beakley. The Macmillan Company, New York, 10, South Audley Street, London, W.1. Price 37s.

Water Power in the Province of Quebec

PART III

(*Concluded from page 418, March 17, 1961*)

Even amongst the wealth of water power resources found along the north shore of the St. Lawrence, the potentialities of the Saguenay River are outstanding. The valley is the centre of Canada's production of aluminium, and the power generated there is equal to about 15 per cent of the total Canadian output of power. A bird's-eye view of all the power development in the valley is given, including some data on the Shipshaw station. Then the newest development, the Chute-des-Passes power station, is described in more detail. Present installations are as sketched on the right.



THE Saguenay valley is a prosperous and agreeable region, characterised by an almost complete economic dependence on the aluminium and the pulp and paper industries. The great bulk of Canada's production of aluminium, i.e. that of the Aluminum Company of Canada, Ltd., has been traditionally in this region, the largest smelter of all being at the vast works at Arvida. Arvida itself is a town of 12,000 people, founded in 1926 by Alcan and populated mainly by that company's employees. Aluminium ingots made at Arvida, and also at the Alcan smelter at Isle Maligne, are taken by rail to the deep water berths at Port Alfred, which is situated at the head of the Ha-Ha bay about 20 miles away. Bauxite is mined in British Guiana and shipped to Port Alfred to supply the two smelters in the valley. Thus the river not only provides such abundance of water power, but also offers ocean ships a generously navigable route almost to the doorstep of the smelters.

Mining the ore, and shipping it to Port Alfred, are the responsibilities of subsidiary companies owned by Aluminium, Ltd., which is the parent company of the vast organisation of which "Alcan" itself is the principal subsidiary. Production was largely concentrated in the Saguenay valley at Arvida and Isle Maligne until the last few years; the complex of smelter and hydro-electric development at Kitimat and Kemano—another "Alcan" venture—came into production in 1954. More recently, also in Quebec, the Baie Comeau smelter, with which British Aluminium Ltd. is associated, was built, in the north shore region of the St. Lawrence whose power schemes we are concerned with; power is taken from the Bersimis station to the Baie Comeau smelter.

British capital and British firms play an important part in this industry and its organisation, for over 70 per cent of the consumption of aluminium ingots in this country is imported from Canada (i.e. 171,000 tons per annum taking the 1957 figure). The rapid completion of Shipshaw power-house during the war, when the demand from the aircraft industry was so pressing, illustrates this point sufficiently without further explanation. The British concern linked with the "Alcan" organisation is Alcan Industries Ltd. (formerly Northern Aluminium, Ltd.); that company's mill at Rogerstone processes Canadian ingots into strip, sheet and extruded sections.

Canadian production of ingots was 646,000 tons in 1958. Of this total, Alcan made 600,400 tons. Table VI shows how the production is distributed between that organisation's various smelters. Alcan's total production is, in round figures, considered to be about a fifth of the world total, the Arvida smelter alone accounting for some 13 per cent of world production.

TABLE VI—*Rated Capacity of Alcan's Smelters, Expressed in Short Tons of Aluminium Ingots*

Arvida	373,000
Isle Maligne	115,000
Shawinigan Falls	70,000
Beauharnois	38,000 (leased to Chrysler, Ltd.)
Kitimat, British Columbia	192,000

WATER POWER FROM THE SAGUENAY

The heading sketch-map and Table V together give a good picture of how hydro-electric exploitation of the Saguenay has progressed over the years, as production of aluminium has expanded. The power is not now tied strictly to the industry, since there are grid connections to the systems of the public supply companies (indeed, local supply of power is in the hands of another subsidiary company of Aluminium, Ltd.) and regular exchanges and sales of power; nevertheless the industry's demands have dominated the growth of the system up to now.

TABLE V—*The Saguenay Catchment and its Power Developments*

Hydrology:	
Catchment area above Isle Maligne	30,000 square miles
Average annual rainfall	38in
Flow figures at Shipshaw (since 1913):	
Long-term average	52,000 cusecs
Maximum daily flow recorded in spring (May–June) flood	Nearly 400,000 cusecs
Maximum daily flow recorded in autumn (October) flood	240,000 cusecs
Minimum monthly run-off (February)	6,800 cusecs
Reliable flow for power available throughout the year, with regulation at the three reservoirs	45,000 cusecs

Reservoirs	Useful storage capacity, c.ft × 10⁶	Top water level, ft a.s.l.
Lake St. John	140*	—
Passe Dangereuse	180	1447
Lake Manouan	80	1643
Total storage	400	

Power Stations	Installed Capacity, MW	Gross head, ft	Date of completion
Isle Maligne	403	110	1926
Chute-a-Caron	224	160	1931
Shipshaw	895	210	1943
Chute-a-la-Savane	202	110	1953
Chute-du-Diable	202	110	1953
Chute-des-Passes	746	636	1960
Total capacity of Alcan system	2,672 MW		

* Corresponding to 12½ft draw down, obtainable at Isle Maligne

The first development, Isle Maligne,† which dates from the period 1922–26, was fundamental in that it controls the outflow from Lake St. John, thus regulating the flow to the stations downstream. Development then proceeded at the sites downstream closest to the centres of consumption, until the construction of Chute-des-Passes power station in virgin country, almost as remote as the Bersimis sites described last week.

The second scheme to be built in the valley, at Chute-a-Caron, was noteworthy for a difficult and unusual problem of river diversion. The river was, in nature, a torrent at this site. Towards completion of the scheme, it had to be diverted from its natural course, and made to flow through the power-house and its associated sluice structures. To achieve this, concrete "abutments" were built on each side of the river, leaving a gap of 90ft to be closed. Then a concrete dam was built, standing on its end on one side of the river. The dam was held in its vertical position by keys, and its outer edge was shaped to conform to the shape of the river bed, which had been accurately ascertained by soundings. Eventually the keys were removed by blasting, and the dam fell sideways into the river, successfully blocking it.

The two post-war developments just above Lake St. John on the Peribonka River, at Chute-du-Diable and Chute-a-la-Savane, were the first semi-outdoor stations to be built in Canada. In general they are not unlike the more recent of the St. Maurice River stations, which we described in Part I.

SHIPSHAW POWER STATION

Shipshaw power station (Fig. 8) is enormous in size, yet characteristically simple in layout, and is thus something of a parallel to the even larger power station of Quebec Hydro on the St. Lawrence at Beauharnois. The principal data relating to the station are given in the legend beside Fig. 9, which is a cross-sectional view through one of the generating sets, and gives a very good idea of the overall design. Apart from the power station itself, construction was characterised by mass excavation through rock, to form

† See THE ENGINEER, February 15, 1929, for a description of the Isle Maligne Scheme.

on the one hand (with impounding embankments), a head race canal starting from the old river bed at Chute-a-Caron and extending 1½ miles to the power station, and on the other a tail-race pond rejoining the Saguenay. The river flows through a gorge close to the power station, and the rock is massive and strong. Thus the excavation is remarkably stark, with nearly vertical rock walls giving almost a cubist touch. This has been set off by the famous light-alloy arch bridge across the river close by, and by laying out the immediate neighbourhood of the power station very attractively as a garden. Flood waters do not pass down the power canal, but are spilled at Chute-a-Caron, where there are eleven spillway sluices each 45ft wide and 33ft deep.

Between 1940 and 1943, Alcan's smelting

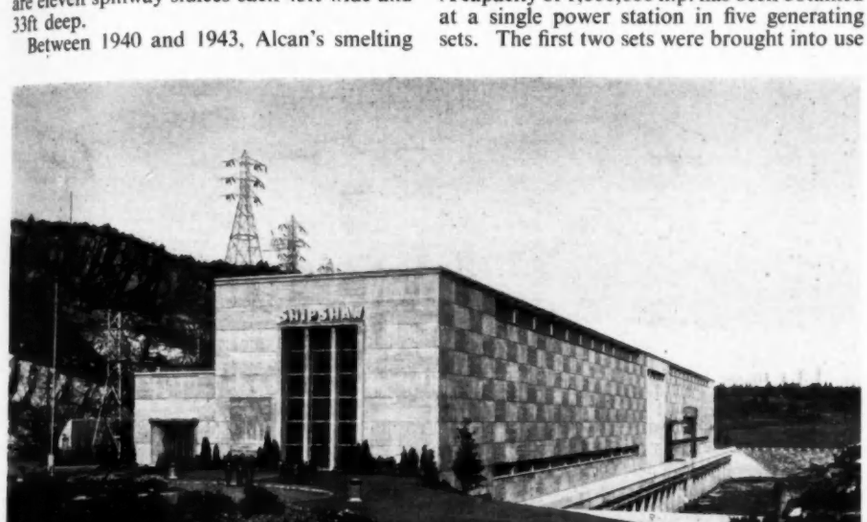


Fig. 8—Shipshaw power station

capacity increased fivefold to a peak of almost 500,000 tons in 1943, due principally to the addition of Shipshaw's capacity to the power system. Construction started in August, 1941, and the first two sets delivered power in November, 1942 ; by December, 1943, the last set was on load, after only twenty-eight months.

At the same time, better regulation of the river flow than could be obtained at Isle Maligne alone, was needed to exploit the new power station to the full, so that two control dams at the head of the Peribonka catchment at Passe Dangereuse and at Lake Manouan‡ were constructed with a speed corresponding to that shown at the power-house.

The former of these two is a concrete gravity dam with a height of 140ft above stream bed level. A road was built up the valley, to give access to it. At Lake Manouan, however, which is still more remote, access to the site was by air, and 2000 tons of materials were taken by air to serve the construction of the dam. Both dams control seasonal reservoirs, and are normally closed in the spring and allowed to fill, until the level of Lake St. John falls and the flow there has to be augmented.

Chute-des-Passes Power Station

From the foregoing description, it can readily be seen how the power stations along the Saguenay built up, spreading away from the load centre—the smelters at Arvida and Isle Maligne—as further sites were needed. After the war, the two sites immediately upstream of Lake St. John were developed at Chute-a-la-Savane and Chute-du-Diable. But when the next stage of development was considered, it was decided that a major new site in virgin territory at Chute-des-Passes immediately below Passe Dangereuse reservoir should be exploited. The intake of the Chute-des-Passes scheme is in the bed of Passe Dangereuse reservoir, and the scheme utilises the head made available by diverting the Peribonka into a system of tunnels about 7½ miles in length running beside the river, as shown in the drawings, Figs. 10–12. A capacity of 1,000,000 h.p. has been obtained at a single power station in five generating sets. The first two sets were brought into use in the autumn of 1959, and the remaining three in 1960. Now the yield of the scheme is being increased by diverting Manouan reservoir into the Bonnard River, which is a tributary of the Peribonka, joining it above Passe Dangereuse. The Manouan, it will be recalled, is also a tributary of the Peribonka, but the two rivers join about 30 miles downstream of Passe Dangereuse, so these diversion works are necessary for the benefit of both reservoirs to be felt at Chute-des-Passes. In continuation of the system of reservoir operation already established, Chute-des-Passes will run at low capacity in the spring, increasing in the summer to full load during the winter.

As at Bersimis, the country had to be opened up before the scheme could be built, and the preliminary works included a new and improved access road 90 miles in length, an airstrip, and a constructional township for 3000 people.

Of the temporary works, the constructional power station was of special interest. Two horizontal-shaft hydro-electric generating sets were installed at a weir, at the position shown in Fig. 10. These two sets generated for forty years at the St. Timothe hydro-electric station which was on the north shore of the St. Lawrence near Montreal (close to Lachine rapids). This station was closed and the two sets removed from it in 1952 ; they were then taken to the site of Lake Cassé dam of the Bersimis scheme and temporarily installed to generate all the constructional power needed there. Then they were moved and reconditioned to serve the Chute-des-Passes works. They appeared to be in excellent condition at this last site, fit for many more years of work.

Design Features

The new power station has an installed capacity of 746MW, and operates with a gross head of 640ft. It is built underground, about three-quarters of the distance along the line of the diversion, which is all in tunnel. As can be seen, it is only slightly smaller than Shipshaw in capacity, and is therefore a really major contributor to the network. Its construction was virtually a tunnelling job, and in many respects was closely similar to the Bersimis I scheme, which we have already described. In fact, the power station has been described, with over-simplification undoubtedly, as "another Bersimis, turned through 90 deg. so that its axis was perpendicular to and not parallel to the strike of the bedding planes of the rock" (i.e. the possibility that the rock might slide out of the side walls, thus weakening the concrete haunches, is minimised).

Two points may perhaps be commented upon in the general design of the scheme. Recent Canadian practice has shown a clear bias towards the underground power station, and probably the three largest examples of this type of construction in the world are at Kemano, Bersimis I and Chute-des-Passes. The economic advantages of this type of scheme are thus well appreciated. At Chute-des-Passes, the power station is, as we have already noted, more or less three-quarters of the way along the diversion, and fairly lengthy tunnels for both head race and tail-race have been driven. This arrangement has been justified by reference to the convenience which it gives for access to the power station and to the intermediate adits on the head race tunnel, though it would appear that either a "head" or "tail" development (i.e. with the power station close to the reservoir or vice versa) would have been possible in principle. Swedish practice favours the "head" development, which is claimed to give a cheaper job, with short penstocks and a long unlined tail-race tunnel. Bersimis I is a "tail" development. At Chute-des-Passes, the "head" arrangement would have been complicated by the fact that an underwater connection has to be made with a reservoir already in existence.

This brings us to the second point of comment. Underwater connections from a tunnel to a lake have been made by blasting in a number of hydro-electric schemes throughout the world, for instance at Loch Treig and Loch Fannich in the Scottish Highlands. The case of Chute-des-Passes is, however, unique on account of the scale of the work (the tunnel has a lined diameter of over 34ft) and also because the intake is close to the dam.

Tunnelling

Performance in the construction of rock tunnels continues to improve. The Chute-des-Passes tunnels, whilst presenting nothing radically new in tunnelling techniques, were yet another example of this trend. The head race tunnel, for instance, is a horse-shoe-shaped lined tunnel with an equivalent (lined) diameter of 34ft 4in and a nominal thickness of the concrete lining of 2ft. Throughout its length, its slope is nowhere greater than about 4 per cent. The tunnel was driven from four faces, two extending from each of two adits. That is, the intake and power station ends of the tunnel were not used for access to faces for the main tunnel drives. Excavation for the power station cavern and its associated tunnels

‡ Lake Manouan, and the River Manouan on which it lies, should not be confused with the reservoirs of the same name mentioned in Part I, which are in the Shawinigan Water and Power Company's system in the St. Maurice catchment.

CANAL—1½ miles long through rock cuts and concrete retaining dams. Minimum width 300ft, water depth 33ft, maximum rock cut 90ft deep, 300ft wide. Headrace tunnels start 20ft below surface.

TRANSMISSION LINES—Shipshaw to Arvida 2·5 miles. Six 154kV double-circuit steel tower lines 477,000 C.M., A.C.S.R. conductor.

TUNNELS—Six 30ft diameter, concrete lined. Total length 740ft.

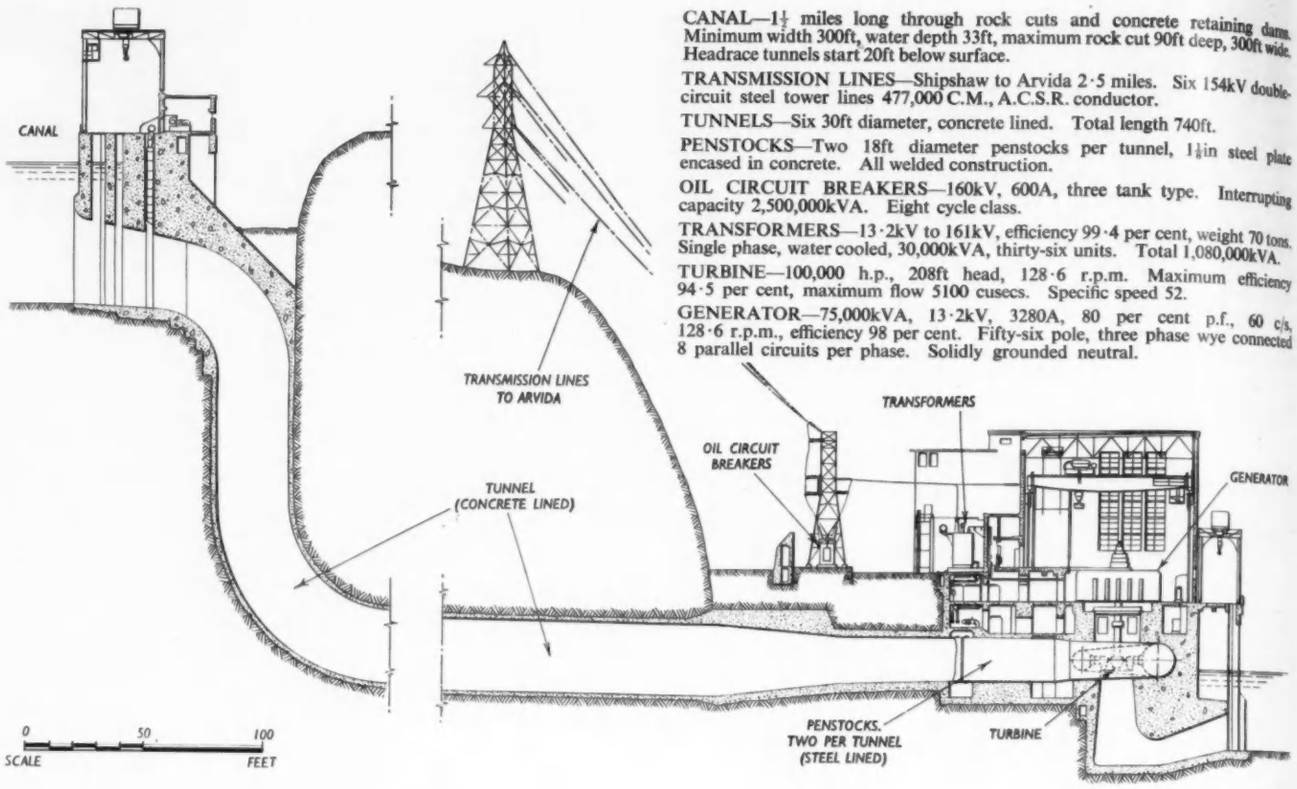
PENSTOCKS—Two 18ft diameter penstocks per tunnel, 1⅛in steel plate encased in concrete. All welded construction.

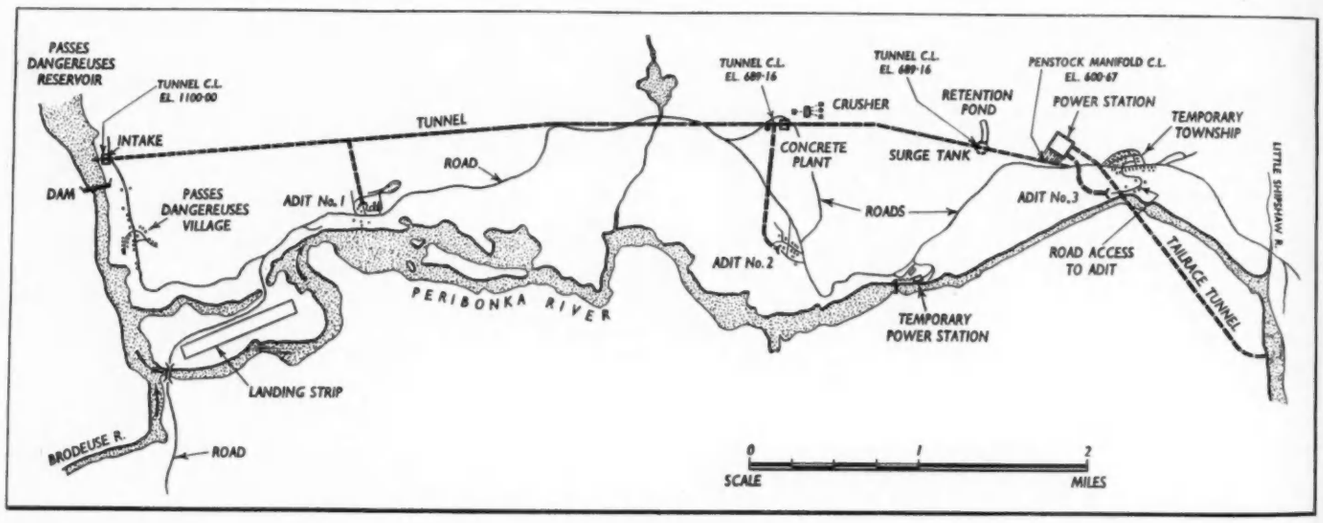
OIL CIRCUIT BREAKERS—160kV, 600A, three tank type. Interrupting capacity 2,500,000kVA. Eight cycle class.

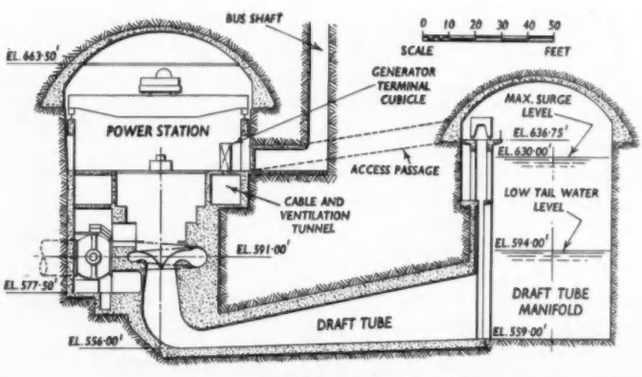
TRANSFORMERS—13·2kV to 161kV, efficiency 99·4 per cent, weight 70 tons. Single phase, water cooled, 30,000kVA, thirty-six units. Total 1,080,000kVA.

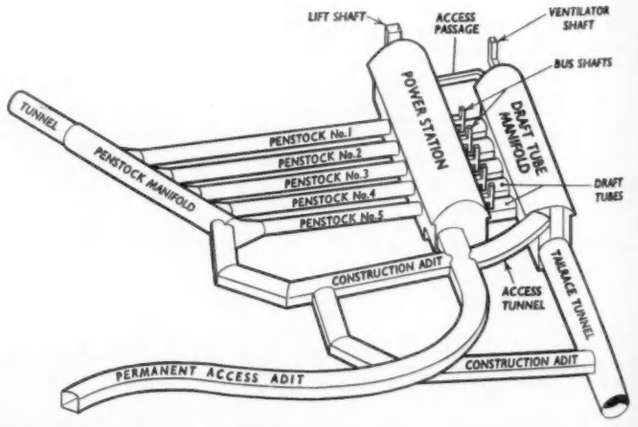
TURBINE—100,000 h.p., 208ft head, 128·6 r.p.m. Maximum efficiency 94·5 per cent, maximum flow 5100 cusecs. Specific speed 52.

GENERATOR—75,000kVA, 13·2kV, 3280A, 80 per cent p.f., 60 c/s, 128·6 r.p.m., efficiency 98 per cent. Fifty-six pole, three phase wye connected 8 parallel circuits per phase. Solidly grounded neutral.









Figs. 9–12.—Details of Shipshaw power station (above) and the Chute-des-Passes scheme (below)

was sufficiently complex without this added complication. And the shaft sunk at the intake end was the sole access to the underwater drive to the intake plug, which although quite short, was much more complicated with a number of special works such as the sump to construct.

At the main drives for the head race tunnel, muck was taken out in two stages, a top heading first and a bench subsequently. The quantity of excavation was 33 cubic yards per foot run, over the whole face, about 15 cubic yards of which was in the bench. At each stage a rail-mounted jumbo with twenty-one drills was used, and muck was taken out of the tunnel by large dump trucks. Roof bolting was extensively used, and steel ribs and "Gunite" mortar were employed in special situations.

Two shifts were worked for six days a week on each face. At adit No. 1, the fastest rate of progress recorded on the top heading (which was equivalent to a 28ft diameter circular tunnel) was 655ft in one week; this figure relates, of course, to two faces, the progress on the one being 330ft and on the other 325ft. The average rate of driving lay in the range 40ft to 60ft per day. The top heading was the critical section, and the bench was taken out a good deal faster, at up to 1000ft per week.

The lining for the whole of the tunnel was concreted with one plant set-up, which worked down from the intake end. The basic element of the set-up was a rail-mounted shuttering assembly which was 160ft long, and shuttered the complete horseshoe (except for the invert) and was fitted with jacks such that the sides could be folded and the arched top section lowered, for striking and moving forward on completion of a concreting cycle.

The concrete was mixed at a station on the surface, close to the adit, where three 4 cubic yard mixers were installed, delivering the mixed concrete by pipe to trucks in the tunnel. The maximum output of concrete was 180 cubic yards per hour and the concrete specifications demanded 525 lb of cement per cubic yard, 2in minimum slump (normally 3in) and 3000 lb per square inch minimum compressive strength. The maximum aggregate size was 1½in, and the shutter was struck twelve hours after completion. The controlling characteristics sought for the concrete were "pumpability" and a good surface finish to reduce to a minimum friction losses in the finished tunnel.

About 1200 cubic yards of concrete had to be placed to fill the shutter, which took about ten hours. One cycle of concreting (i.e. 160ft of tunnel) was completed every twenty-four hours throughout a six-day week when this work was in full swing. Dump trucks brought the concrete in 12 cubic yard batches to the plant where they drove up a ramp onto a turntable where each batch was deposited into a hopper. Below the hopper, a horizontal shaft with paddles remixed the concrete prior to passing it, on a conveyor, to a central hopper serving the concrete pumps. Three 8in pumps then delivered the concrete, through the three 8in diameter pump lines positioned on "spacers" (i.e. rail-mounted gantries) to the shutter. Vibration was done through ports in the shutter. The whole train of equipment was rail-mounted, and gradually pulled back, extending the spacers, as the 160ft length of shutter was filled. A trimming gantry followed behind the train.

For special works, such as shaft sinking, experienced labour was brought in. At the gate shaft concrete was dropped down a 280ft pipe, remixed in a paddle hopper, and then pumped to forms in the section of tunnel under the lake. A rubber-tyred jumbo was used in this length of tunnel.

Although both the power station and tail-race excavations (Fig. 14) were on a vast scale, neither presented undue difficulty. The tail-race tunnel is unlined, and has an equivalent diameter of 48ft. Roof bolts in this tunnel were of light alloy, as an anti-corrosion measure, and it is thought this is the first occasion when roof bolts of this material have been used. The power station was excavated out of paragneiss rock, and then built in reinforced concrete, but the structure of the control room is of structural steel assembled with fitted bolts. The relatively rapid assembly of this structure eased the complicated schedule of construction and installation in the power station cavern.

The accompanying sketch, Fig. 13, gives a good idea of the general technique of blowing the plug of rock in Passe Dangereuse reservoir, and also shows the permanent installation of screens and gates at this end of the tunnel. The problem was investigated on a model. It was without precedent in that a plug 100ft in diameter and 50ft thick and containing 13,000 cubic yards of rock had to be blown out, and in that Passe Dangereuse dam was only 200 yards distant.

Fig. 14—The draft tube manifold of the Chute-des-Passes power station

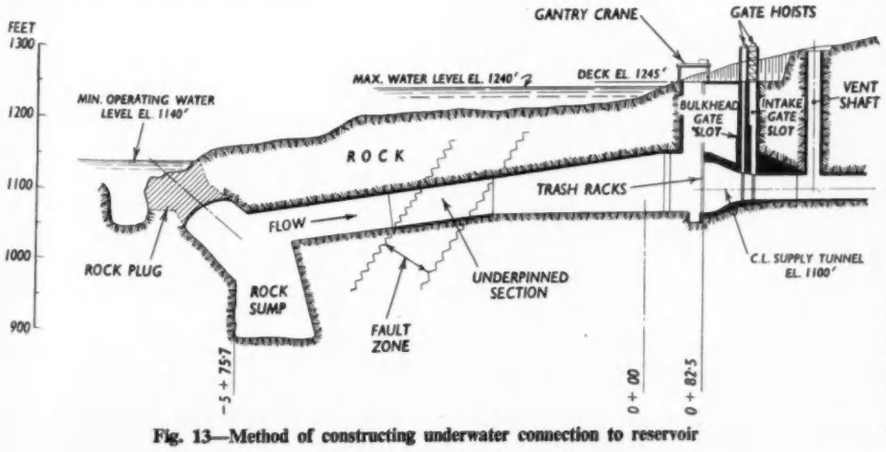


Fig. 13—Method of constructing underwater connection to reservoir

The Power Station

Keeping to "the schedule" was paramount on this as on virtually all Canadian constructional sites. But during the constructional period, some economic recession was felt, and there was, in particular, less demand for aluminium than had been anticipated. For once, therefore, the inexorable "schedule" was slowed down. Even so, construction started in October, 1956, and the first set generated power in August, 1959. The full capacity of the station is now available. The principal statistical data are given in Table VII.

The head race tunnel slopes fairly uniformly throughout its 5 mile length, steepening only slightly downstream of the surge shaft. The latter widens out to a simple surge tank, which overflows at the 1280ft level, a pond catching the overflow and redirecting it back into the tank. The tunnel ends in a concrete-lined manifold, from which five steel-lined penstocks branch off to the turbines in the power station. The penstocks run parallel to each other, practically horizontally, and at an obtuse angle to the manifold.

The penstocks are 15ft 0in in diameter at the manifold, reducing in steps, with short

TABLE VII—*The Chute-des-Passes Power Development*

Power Generating Data :	
Nominal installed capacity	5 × 149MW
Normal gross head	636ft
Range of gross heads	100ft
Rated flow at mean head and nominal capacity	14,750 cusecs
Maximum flow through power station	18,000 cusecs
Guaranteed firm power output	491MW
Generating conditions	14·4kV, three-phase 60 c/s
Main transformers (on surface)	
Number	15+1 spare
Capacity	33/44/55/66MVA
Type	ONS/ONP/OFP/OFFP
Normal operating speed of turbines	200 r.p.m.
Runaway speed	376 r.p.m.
Load on thrust bearing	966,000 lb
Diameter of turbine runner	145in
Power Station :	
Length	460ft
Width	70ft
Height	110ft
E.O.T. cranes	Two of 210 tons, spanning 67ft
Centre-line spacing of generating sets	60ft
Volume of excavation in power station	130,000 cubic yards
Volume as cubic yards per kilowatt installed	0·175 cubic yard per kilowatt
Head race tunnel :	
Length	30,854ft
Equivalent diameter	34ft 4in
Nominal thickness of concrete lining	2ft
Total lengths of adits serving tunnel	9,256ft
Tail-race tunnel :	
Length	9,000ft
Nominal equivalent diameter (this tunnel is unlined)	48ft
Surge shaft and chamber :	
Diameter of surge shaft	30ft
Height of surge shaft	348ft
Diameter of surge chamber	130ft
Height of surge chamber	250ft
Principal quantities for the scheme :	
Excavation	3,000,000 cubic yards
Concrete	578,000 cubic yards
Some principal levels :	
Normal reservoir top water level	1,240ft
Minimum operating level of reservoir	1,140ft
Tunnel invert level at intake	1,080ft
Surge tank overflow level	1,240ft
Turbine centre-line level	591ft
Normal top water level at tail-race tunnel portal	604ft
Minimum low water level in tail-race	594ft
Invert level of power station tail-race manifold	559ft
Maximum surge level in manifold	630ft
Note : These levels are to a datum which is about 207ft above mean sea level.	
Approximate cost of scheme	150 million dollars.
Cost per kilowatt installed	200 dollars

transition lengths, to 14ft, 12ft and 11ft, successively ; the shortest penstock is 256ft long. Each one ends in a 132in spherical valve positioned in the main hall of the power station. The thickness of the steel plate of the penstocks is 1·5in to 3in, and it is classified as ASTM A201, grade B, firebox quality, fine-grain practice. It is coated with bitumen externally for some distance back from the power station as well as internally. Relative movement between the penstock and the rock is thus allowed for next to the power station. A design head of 920ft was assumed for the penstocks.§

The power station itself (Fig. 15) is very simple and straightforward for an installation of such size. The transformers are on the surface 450ft above, and five vertical shafts, one for each generating set, lead the bus bars up to them. There is also a lift between the transformer and switching station on the surface and the power station below. An access tunnel for vehicles leads into the station from the valley.

The tail-race of each set leads into a common manifold, which comprises a large vaulted chamber with a free water surface, where surges in the tail water system are damped out. One draft tube gate is available, and can be placed by crane to close off any draft tube which is to be dewatered. The tail-race tunnel operates under a small head ; it leads away from the manifold at a 7 per cent. slope. Further along the tunnel the slope changes, and it terminates with a negative slope of 8½ per cent in the short length next to the portal in the Peribonka River.

The turbo-alternator sets are noteworthy as being the largest on the North American continent. The nominal output of each of the five sets is 200,000 h.p. (i.e. 150MW) at a net head of 540ft, but at a maximum head of 640ft an output of 265,000 h.p. is achieved. The turbines are Francis machines, and the alternators are of umbrella design, both machines following established practice in their general design. One point of special interest, however, lies in the governing. The turbine governors are magnetic amplifier devices which if desired will permit control of all five sets in the power-house as a single unit.

Power is taken from the Chute-des-Passes transformers at 345kV over 100 miles of transmission line to Isle Maligne where it is fed into Alcan's grid. Several of the towers on this single circuit 345kV line are of a rather novel design, which can be assembled and erected very rapidly. These towers are " V "-shaped, each leg of the " V " being of braced square cross section, and made of light alloy scantlings. A beam across the top of the " V " carries the insulators, and the tower is secured by four guys. The leg scantlings are assembled into 21ft long sections, six to ten of which are needed for each tower. A section can be handled by two men, and the light alloy in a tower 96ft high (i.e. with ten leg sections) weighs 2400 lb. The tower is assembled on the ground, and then hauled up by rotating about the ball joint at the base of the " V."

Construction of the Chute-des-Passes scheme followed conventional methods of organisation, and design and supervision was the responsibility of the consulting engineers, H. G. Acres and Co., Ltd., of Niagara Falls. The main contractor was a consortium of three firms known as the Perini-McNamara-Quemont Construction Company. The five turbines were designed by the English Electric Company, Ltd., and made by that concern's Canadian associate, the John Inglis Company of Toronto. The alternators were made by the Canadian General Electric Company, Ltd., and the five big spherical valves by Dominion Engineering, Ltd.

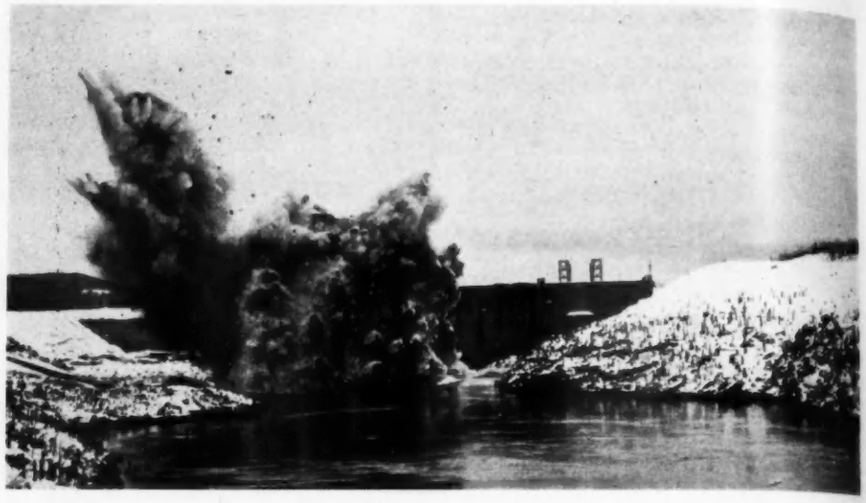


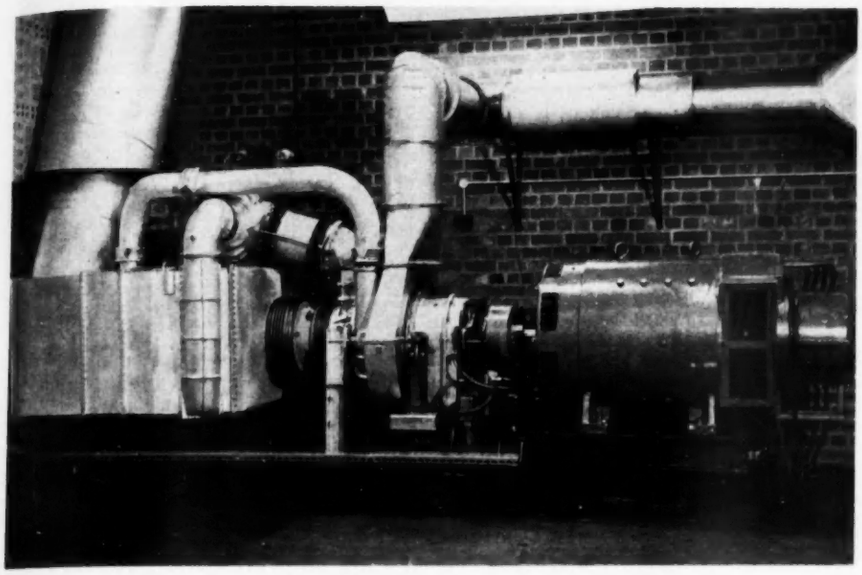
Fig. 16—Blowing the plug of the Chute-des-Passes tunnel in April, 1959. Note the low level of the reservoir

§ The penstocks design for Chute-des-Passes, Bersimis I and Bersimis II, is explained in detail in the paper " Design of Large Pressure Conduits in Rock," by F. W. Patterson, R. L. Clinch and L. W. McCaig, A.S.C.E. Proceedings Paper 1457, December, 1957.

Fig. 15—The underground power station at Chute-des-Passes, looking towards the control room

Industrial Gas Turbine

A simple gas turbine for applications where fuel costs are low is distinguished by having an axial flow turbine. A version with a heat exchanger having mixed cross- and contra-flow is under development.

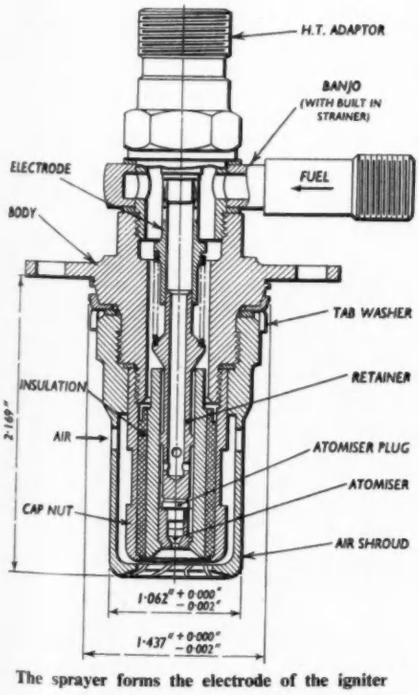


An experimental installation showing the gas turbine, fitted with a heat exchanger, driving an electrical generator through a centrifugal clutch

AS is well known, the Austin Motor Company, Ltd., has for many years been working on gas turbines, primarily for vehicle applications ; in 1955 at the Jubilee of the firm there appeared a " Sheerline " saloon fitted with a 120 h.p. free-turbine engine. In order to exploit the experience that has been gained, the firm decided to market an engine suitable for the many applications which are less demanding than vehicle service, such as stand-by generating, fire-fighting pumps, starting jet propulsion engines, and marine auxiliary and propulsion machinery. There has therefore been evolved an engine of 250 b.h.p. known as the " 250 " : it is available either as a shaft-power engine or coupled through a centrifugal friction clutch to either a 160kW, 1500 r.p.m. alternator or a centrifugal pump.

The new engine is thermodynamically and aerodynamically simple: its fuel consumption is 1·1lb per h.p.-hr at full load. The automotive engine, being designed initially for recuperation, had two stages of compression, each based on the Rolls-Royce " Merlin " centrifugal supercharger. The industrial engine has a single compressor scaled up to handle considerably more air at a design pressure ratio of 3·5 ; as usual, the twisted and the purely radial sections of the vanes are formed in two separate workpieces for ease of machining. The rotor is milled out of forgings of RR58, and shrunk on to the shaft.

The bladed diffuser merges into a volute leading to the single " elbow " or side-entry combustion chamber, a Lucas product.



The sprayer forms the electrode of the igniter

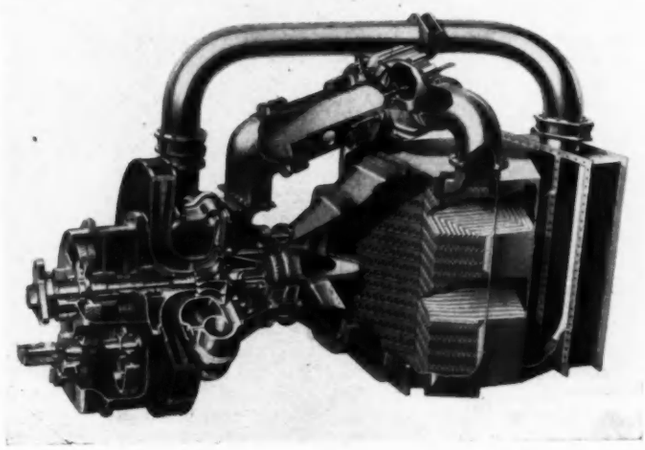
One distinctive feature of the engine is that the Simplex sprayer is part of the igniter ; the sprayer is the central core of the igniter, separated from the outer casing by an insulating sleeve at the swirl chamber end and by the pressurised fuel in the body of the device. As is well known, for a pulse of sufficiently high energy oil acts as a dielectric rather than, as on a conventional " sparking " plug, a leakage path. The nose of the combined sprayer-igniter carries cooling air path in the usual way.

The gas, at a temperature of 800 deg. Cent. at full load, is directed back to the turbine, which, in contrast to many of the simple industrial gas turbines, is a two-stage axial flow component. The nozzles are cast in segments in H.R. Crown Max., while the blades are machined in Nimonic 90 and fitted into their separate wheels by the classical " fir tree " roots. The two wheels and the large-diameter shaft are aligned by Hirth couplings, and the entire assembly secured by a central tie bolt. It is interesting to note that the maximum speed of 29,000 r.p.m. is below the first critical speed of the assembly.

The construction of the two-stage reduction gearing, which normally has an output at 1500 r.p.m., can be perceived in the " ghosted " drawing. The main power train is composed of double helical gears, each split on the plane of symmetry for ease of manufacture, and are free to align themselves axially. Notice that one pair run with the apices leading and the other, trailing.

The auxiliaries include a Lucas swashplate pump, 24V starter motor, and a double rotor Hobourn Eaton pump which both provides the engine lubricating oil pressure and circulates the oil through a cooler. This gas turbine is unusual, possibly even unique, in that it runs on straight mineral oil ; however, if the set is shut down immediately after running at full power, " barring over " is necessary to the extent of performing one start cycle with the fuel off. The starting procedure is automatic after the start button is pressed, the fuelling programme being predetermined on a base of time. Shut-down is also automatic in the event of loss of oil pressure, of overspeed or over-temperature.

This engine was demonstrated recently to the Press, both driving an alternator and pumping water for fire-fighting ; to allow the pump to lift water, it is fitted with a small exhauster for priming. The alternator plant was observed to run unloaded at 1525 r.p.m. within the prescribed 2 per cent run-up, with a T_{max} of 600 deg. Cent. In view of the foregoing remarks about the use of straight mineral oil, it may be of interest to record that an instrumented



Internal details of the recuperative engine : notice the full-radial intake which allows a considerable shortening of the high speed shaft to the gearcase

engine was limited to a turbine bearing temperature of 160 deg. Cent.

There is already under development a recuperative version of the engine ; this will run at a higher T_{max} in order to maintain the same rated output. The heat exchanger is of an interesting configuration affording largely contraflow conditions but with the simple ducting of a cross-flow unit. The construction can be followed in the diagram ; the heat exchanger is essentially a secondary surface design and the " fins " are used to direct the flow. The gas passes straight through the matrix along one or the other arm of a V. The compressed air enters in between the arms at the top of the V and flows outward to within the matrices, then turns down the arm, and finally turns outward again, leaving on either side at the bottom of the V. The experimental units have been brazed up from mild steel (distillate or gaseous fuel is specified) ; sample matrices shown to us had passage depths of about $\frac{1}{16}$in for the air and $\frac{3}{16}$in for the gas. As the diagram shows, the elbow combustor of the basic engine is replaced by a symmetrical chamber in the recuperative unit.

Another development which is envisaged is a free turbine unit engine, retaining the two-stage high-pressure turbine and adding a third wheel on a separate shaft. Clearly, the l.p. shaft cannot pass through the h.p. line with the present construction, and so a fairly extensive rearrangement of the engine to bring the reduction gear to the exhaust end will be required.

Refinements in Traffic Lights

ON March 16 the Traffic Engineering Study Group of the Institution of Civil Engineers met to discuss a paper on " Future Developments in Traffic Signals," presented by F. W. Webster, B.Sc., Ph.D. Principal Scientific Officer, Traffic and Safety Division, Road Research Laboratory. Mr. H. S. Andrew was in the chair.

Dr. Webster reported in his paper that almost all fixed-time signals have now been replaced in this country by vehicle-actuated ones. The latest type provides automatically for variation of the minimum limit of the green period, for a slight extension of the green period, and for an all-red period, when traffic conditions call for such measures. The standard specification remains under review, however, and the meeting was told of impending changes, including a reduction of the minimum green period from eight seconds to seven seconds. The maximum duration of the green, which is at present selected in steps of five seconds at one end of the range and 7½ seconds at the other, will be scaled in standard increments of four seconds, and the range will extend to sixty-eight seconds instead of the present sixty seconds. The maximum green for which particular traffic lights are set is not yet variable automatically, but the meeting was assured that this development will come ; it will enable traffic lights to cater more flexibly for the busiest roads (especially multi-lane roads) where now it often happens that vehicle-actuated lights act virtually as fixed-time lights because of heavy flows.

In addition, the speed-timing device in detector pads is to be modified so that, in effect, the lower limit at which an approach-vehicle demands a green extension will be 15 m.p.h. instead of the present 10 m.p.h.; but, at the other extreme, there remains the problem of improving the flexibility of traffic lights located on high-speed roads. The Group was especially interested to hear, and discuss, how the laboratory is approaching this problem, which consists essentially in helping the fast driver who, under the present system, finds himself confronted with a change from green to amber while he is still an appreciable distance short of the lights though too near them to be confident of braking successfully. With a three-second amber, and an approach speed of 50 m.p.h. for instance, he will be safe to continue if he is within 260ft of the stop-line when the amber appears, but his comfortable braking distance may be 440ft ; between these two critical distances he is liable to have an awkward decision forced on him. One possible solution could come through the use of a remote roadside warning signal, suitably controlled from the lights ; but the meeting was told that the authorities had rejected this on the grounds that it would add to the multiplicity of signs and signals that already distract the driver. Reliance is likely to be placed on a concealed speed-timing detector, 500ft short of the stop-line, from which any necessary green extension will be demanded, instead of from the detector-pad proper (90ft to 130ft short of the stop-line). But the demand for a green extension will not be transmitted at once ; it will be delayed until the vehicle has reached its critical zone, and if meanwhile the lights have changed to amber then, of course, the demand will not be transmitted at all, for the vehicle will be able to stop comfortably. It was made clear to the meeting that this will not entirely eliminate the problem ; in a stream of vehicles the one next behind the one granted the final green extension may also be in the critical zone. The saving grace, one speaker pointed out, is that cross traffic waiting at the lights is habitually timid when very fast traffic has been crossing its bows.

The Group discussed various uses of presence detectors (which detect vehicles moving or stationary) in conjunction with traffic lights. They are already in use experimentally at certain signal-controlled roundabouts, both on the approaches and in the form of a loop round the central island ; they serve to withhold a green period, or impose an all-red, as may be necessary to prevent congestion and consequent locking of the traffic. Another use predicted for them was to deal with the situation that arises when the queue at one intersection stretches back to the previous one ; detectors under the tail of the queue will be able to prevent the green from being shown, except as as a filter-left, until the crossing is clear. Their probable use as governors of the variable maximum green, discussed earlier in the proceedings, did not pass unquestioned ; an instrument engineer suggested that a straight count of the vehicles passing in the priority direction during one right-of-way period might be the best criterion for varying the next period ; the density of the traffic ascertained by means of these detectors, would be a more complex criterion to feed into the mechanism of the lights, though he had no doubt it would do. In any event the meeting was assured that there would be no shortage of applications for presence detectors, especially in cities.

The difficulty (or impossibility) of achieving a really smooth flow of traffic through a series of intersections figured in many of the contributions to the discussion, but in the end the true " green-wave " seemed as remote an ideal as ever. The programme for the lights along a two-way street is necessarily a compromise, otherwise the complementary wave would be red ; nevertheless the results can be valuable. The meeting was told of London surveys showing that in Oxford Street a vehicle has a 63 per cent expectancy of being held up at the first traffic lights, but only 48 per cent at each of the succeeding fifteen ; and the average wait at the first lights is thirty-three seconds but only nineteen seconds at the others. This part of the discussion may have had little to do with developments in traffic lights, but it showed that the Group are very much alive to the problem as a traffic engineering one ; they will no doubt return to it in due course.

This report has covered only developments of the " near future," as Dr. Webster classified them, and indeed there are two more to mention. The first concerns the temporary red and green signals used for single line traffic alongside road works ; it was announced that these are likely to be developed in vehicle-actuated form, to a new, simplified official specification. The other development concerns signal-controlled pedestrian crossings ; a new operating mechanism will probably require the pedestrian to keep the button pressed, or the handle pulled, in order to place his demand ; if he takes advantage of a gap in the traffic, and crosses before the lights have changed in his favour, the demand will lapse. At the present stage of research it seems that the critical pedestrian flow, at which a signal-controlled crossing becomes preferable to a zebra crossing, is about 1000 pedestrians an hour.

Technical Reports

Determination of the Cement or Lime Content of Cement- or Lime-Stabilised Soil. Road Research Laboratory Report. H.M. Stationery Office. Price 1s.—The Road Research Laboratory has used three methods for the determination of the cement content of cement-stabilised soil which can also be used without modification for the determination of lime in lime-stabilised soil. These methods are the British Standard ; the E.D.T.A.; and the flame photometer method, none of which requires a particularly detailed knowledge of analysis and are all applicable to all soils except those containing a large or variable amount of calcium (or magnesium in the case of the E.D.T.A. method). The E.D.T.A. and the flame photometer methods described and recommended in the publication were found to be appreciably quicker than the British Standard method, although all were accurate to 0·2 per cent of cement.

Guss im Schiff. Published by Zentrale für Guss, verwendung (Z.G.V.), Düsseldorf, Sohnstrasse 70-German Federal Republic. Free on demand.—No. 8 of the series " Casting and its Application " deals with the development of the use of castings in naval construction, and the application of ferrous and, in particular, steel castings in that field ; a special section is devoted to the more recent methods of composite construction while combining castings and welded elements. Designers will find useful the survey of quality grades at present available, and the description of actual components for reciprocating engines, including the modern steam engine, and steam turbines, as well as the tabulation of physical and technological properties which are included.

Noise Attenuation Properties of Flexible Piping. By J. Kane. N.E.L. Fluids Note No. 90. National Engineering Laboratory, East Kilbride, Glasgow.—It has been shown by the National Engineering Laboratory that noise in oil piping systems can be reduced by including a chamber containing sound-absorbent materials. This report covers an investigation of the possibility of replacing the chamber by a length of flexible pipe, although it does not attempt comparison of the two methods, either in performance or cost, volume, &c. An assembly of a series of three rubber convolutions with a total length of 8in was found to give a large (*c.* 40dB) attenuation of virtually all motions above 200 c/s.

SHORTER REPORTS

Doppler Navigation for B.O.A.C.

It is announced that the British Overseas Airways Corporation is to equip its fleet of nineteen "Comets" with the AD2300A Doppler navigator of Marconi's Wireless Telegraph Company, Ltd., Chelmsford, Essex. This is a basic Doppler sensor working on a frequency-modulated c.w. system. It will operate an indicator drive unit providing outputs for a counter showing miles flown and a two-pointer instrument showing ground speed and drift. The other components of the installation are a transmitter/receiver unit with a transmitting klystron manufactured by the English Electric Valve Company, Ltd., a tracking unit containing the frequency-measuring circuits for determination of ground speed and drift angle, and an aerial unit comprising a linear slotted waveguide array in a directional horn assembly.

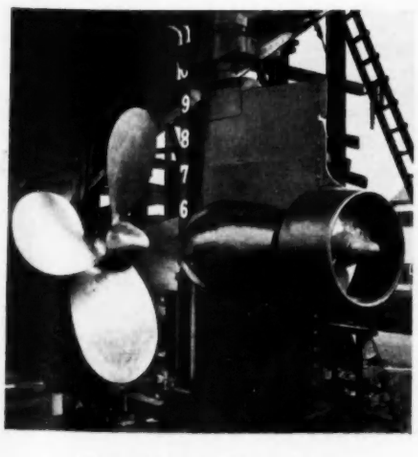
The B.O.A.C. decision to install this equipment follows evaluation trials carried out since 1958. Flights were made both with the 2300A equipment and later with the 2300B, feeding into a computer and an associated display. A characteristic of the equipments is that should the Doppler signal fail, computation of distance run continues, using the last known ground-speed and drift angle. On one of the B.O.A.C. flights the duration of "memory" computation did not exceed four minutes on any occasion in 80·3 hours of flying. In a series of ten flights totalling 653·5 hours, "memory" durations of between two and four minutes occurred on forty-seven occasions, between four and six minutes on eleven occasions, and between six and eight minutes on ten occasions. Longer durations did not exceed one per flight.

Fisheries Research Vessel "Clione"

The fisheries research ship "Clione" has been completed by Cochrane and Sons, Ltd., to the order of the Ministry of Agriculture, Fisheries and Food and is a smaller edition of the "Ernest Holt," constructed by the same builders some years ago. Measuring 154ft length overall and having a length between perpendiculars of 135ft by 29ft beam and moulded depth of 14ft 3in, the ship has to meet the draught restrictions at Lowestoft and is intended for special services at the Ministry's laboratories at that port. The hull form is based on tank tests to provide propulsive efficiency combined with seaworthiness. Of conventional trawler profile, the "Clione" is arranged for trawling on the starboard side, leaving the port side for hydrographical surveys and plankton research work, while arrangements have been made for light pelagic fishing over the stern. In the space normally allocated to the fish hold, is a 35-ton tank intended to carry 20 tons of live fish for transplantation experiments. Accommodation is provided for a number of scientists together with adequate laboratory space.

A Pleuger Active rudder, illustrated herewith, ensures maximum manoeuvrability at slow speed and enables turns to be made with the minimum of ahead movement. This arrangement ensures that effective thrust is in line with the rudder, the maximum helm being 40 deg. Power is provided by a 100 b.h.p. squirrel cage a.c. motor which is water filled and lubricated. The propeller has a thrust of 2750 lb capable of giving the ship a speed of 5 knots. Among the equipment is a marine log able to provide accurate indications at speeds as low as 1 knot, and a Kelvin Hughes Fisherman's Asdic which is a combined echo-ranging, echo sounding device enabling a lane of water 2 miles in width to be searched for the presence of fish. Marconi marine radio-telephone and direction finding facilities are provided.

Propulsion is by a Mark 6ATCM Ruston and Hornsby four-stroke, direct injection, turbocharged and intercooled diesel engine having six cylinders of 12½in bore by 14½in stroke and developing 1000 b.h.p. at 500 r.p.m. Power is transmitted through a Modern Wheel Drive reverse reduction gearbox having an ahead ratio of 2·65 to 1 and an astern ratio of 2·9 to 1, and giving the propeller a speed of 190 r.p.m. The propeller shafting runs in Cooper roller bearings, and the engine is operated manually or through Bloctube controls from the wheelhouse. A 212kW generator powered by a 340 b.h.p. Ruston and Hornsby Mark 6 VCBXZ diesel engine provides power for the Elliott and Garrood main trawl winch, which has two drums, each having a capacity of 1200 fathoms of 2¾in wire rope, and is driven by a 260 b.h.p., 650 r.p.m. motor. Two 102kW Laurence Scott generators, each driven by a Ruston Paxman Mark 4 RPHZ diesel engine developing 153 b.h.p. at 1200 r.p.m., supply the main d.c. power, while auxiliary power is provided by a 20kW diesel-driven generator to which is clutched an air-cooled air compressor.



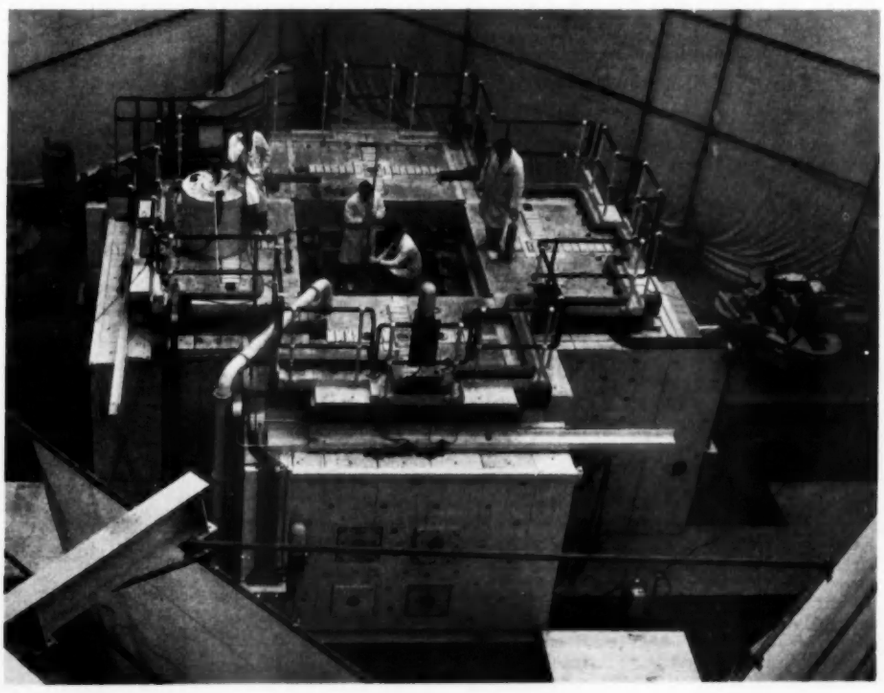
Active rudder with Pleuger motor

"Nestor" Reactor Goes Critical

A new 10kW reactor, "Nestor" (Neutron Source Thermal Reactor) illustrated below, went critical at the Atomic Energy Establishment, Winfrith, on March 13, 1961. Its function is to act as a source of neutrons for sub-critical assemblies of nuclear fuels and moderators, to predict the behaviour of full-scale reactors. The reactor core, control gear and instrumentation was designed and installed by the Hawker Siddeley Nuclear Power Company, which modified the design of its "Jason" reactor to enable up to five sub-critical assemblies to be driven simultaneously by the reactor. This concept represents a major advance in the use of a reactor as a neutron source. The Turriff Construction Corporation, Ltd. was responsible for the installation of the special shielding and the civil work generally.

"Nestor" is fuelled with an alloy of highly enriched uranium and aluminium in the form of aluminium-clad plates arranged in an annulus around a graphite cylinder, and natural water is used both as coolant and moderator. The reactor has control and safety rods, and additional control is possible by varying the water level. The experimental assemblies will be placed in "caves" formed in the shielding at the sides and above the reactor. All shielding is arranged to be demountable so that the caves can be rebuilt to accommodate major changes in the requirements of the experimental programme. The sub-critical assemblies adjacent to "Nestor" will be used to obtain experimental data for power reactors moderated by graphite, natural water and heavy water.

The reactor can be operated at 10kW (heat) giving a thermal neutron flux of 10^{11} neutrons per square centimetre per second in the centre of the core and of up to 10^{8} per square centimetre per second in the sub-assemblies. The thermal neutron flux for each sub-critical assembly can be varied by altering the reactor power level, by using neutron shutters or by rearranging the fuel loading in the annular core.



Loading a highly enriched uranium fuel element into "Nestor" reactor during the initial approach to criticality at the Atomic Energy Establishment, Winfrith

SHORTER REPORTS *(continued)*

Evaporator for Motorships

To the range of marine equipment which it manufactures, Caird and Rayner, Ltd., has added a new unit. This has been evolved after extensive research and experiment and is the " Movac " sea-water evaporating and distilling plant which utilises the heat in diesel engine jacket cooling water as the operating medium. Fresh-water is a relatively costly item, due to the weight and the storage required, and also to purchase. Where steam is available then there is heat in a convenient form for distillating fresh-water from sea-water but when this is not so then other sources of heat must be used. For the design of the new auxiliary, the principle that sea-water can be evaporated at a boiling temperature of 100 deg. Fah. with a high vacuum in the evaporator has been adopted. Since the temperature of diesel jacket cooling water is about 140 deg. to 150 deg. Fah. it is a suitable heat exchange medium.

The " Movac " plant is a self-contained unit in a horizontal cylindrical shell which is divided horizontally by a plate which holds the vapour baffles and provides a bottom to the condenser section. A portion of the sea-water, from the ship's services, which is circulated through the condenser is led as feed into the evaporating chamber and is heated by the diesel engine jacket water which passes through the tube nest in the chamber. The vapour generated passes to the condenser unit and the distillate is withdrawn by an extraction pump. About one-third of the salt water feed is converted into distilled water, the remainder being withdrawn to avoid build up of brine density. Apart from electric power for the pumps only waste heat is used, and the low boiling temperature coupled with low brine density keeps scale formation to a minimum. For use in port a steam coil can be fitted and using steam at 180 lb per square inch the equipment can provide about half its normal rated output.

The plant is designed to meet the requirements of Lloyd's Register, Ministry of Transport and other classification societies, and is available in sizes having a distillate output ranging from 5 tons to 30 tons in twenty-four hours.

[Reply Card No. E4661]

Semiconductor Applications Laboratory

AN applications laboratory for proving the design and serviceability of silicon semiconductor devices has recently been completed by Ferranti, Ltd., at the company's Gem Mill factory, Oldham, Lancs. This new laboratory provides a floor area of approximately 3000 square feet, for carrying on the work which was begun in 1957 at the Moston factory of Ferranti, Ltd., since when a considerable amount of information has been accumulated on the behaviour under almost all possible operating conditions of the range of silicon semiconductor devices produced by the company. Development engineers from other companies seek the assistance of the laboratory in theoretical and practical problems arising in circuitry design. In order to provide satisfactory solutions to these problems, it is necessary in some instances for customers' circuits to be set up in the laboratory to ensure that conditions will be similar to those encountered in operation. Evaluation of experimental devices is also carried out and recommendations are subsequently made to the company's development engineers as to the methods which might be adopted in the future to improve the devices.

Because of the greater emphasis being placed on voltage surges which prototype devices must withstand under operational conditions, particular attention is paid to surge testing in the laboratory, and special equipment has been built for this purpose. In most instances surges up to 200 times the normal current rating are applied to devices for varying periods of time. One project now being carried out by the laboratory is the construction of a scale model of a 110kV, 2A, e.h.t. supply, for investigating problems associated with connecting large numbers of silicon rectifiers in series. These include unequal reverse impedances, unequal hole storage characteristics arising from the rapid rise times associated with the circuitry, and the problems surrounding the physical layout of the completed equipment, which will accommodate about 2000 rectifiers. Much experimental work is also carried out on the design of rectifier stack assemblies with the object of making them lighter and stronger. Hole storage characteristics and decay times of devices are being continuously investigated.

Machine Tool Conference

FOLLOWING the success of the first Machine Tool Design and Research Conference which was held in Birmingham in 1960, a second conference has been arranged to take place at the Manchester College of Science and Technology during the week beginning September 25, 1961. The preliminary announcement states that this conference is intended to deal with : recent researches in manufacturing methods, such as machining or forming ; results of recent investigations into the behaviour and performance of machine tools employed for the execution of the above processes ; recent developments in the design and manufacture of machine tools and machine tool control systems ; and productivity and economics of machine tool applications.

Papers will be presented by authors from the Continent and prominent research and development engineers drawn from industry and the universities of this country. In addition to the papers, visits are to be arranged to appropriate research laboratories and machine tool manufacturing establishments in the North of England.

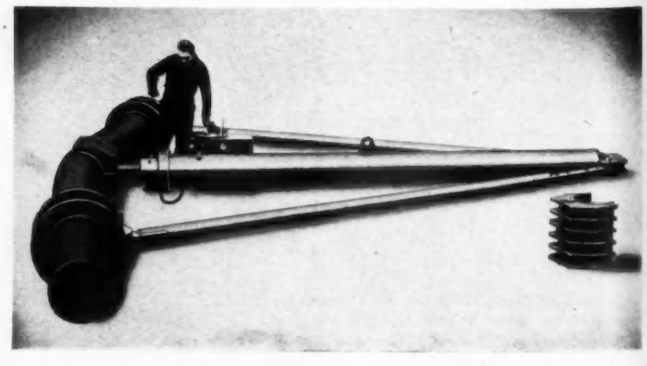
To facilitate the organisation of informal discussion groups and film shows, &c., in the evenings, accommodation for delegates will, as far as possible, be arranged at Woolton Hall, Manchester University. Inquiries in connection with the conference should be addressed to Mr. J. P. Mabon, Manchester College of Science and Technology, Manchester, 1.

Large Capacity Portable Pipe Bender

A PORTABLE hydraulically operated pipe bending machine with a capacity for bending up to 18in outside diameter by ½in wall thickness mild steel pipe is now made by Chamberlain Industries, Ltd., Argall Avenue, London, E.10. This machine is designed for use in the field for large diameter pipe laying applications, and the power required is provided by a simple air/hydraulic pump which can be driven from a small compressor supply or an air line.

To ensure that the machine, illustrated below, is easily transportable, the conventional type of forming head has been replaced by two pivoting arms to which the pipe clamps are fitted, thus permitting the pipe to be bent to form part of the machine's structure. The arms are adjustable for length from the rear of the machine, this adjustment being used to lengthen the ram stroke and thus increase the angle of bend obtainable. A high-pressure relief valve safeguards the hydraulic circuit against overloading and it is stated that under normal operation a 10 deg. bend can be made in one thrust in a length of 18in o.d. by ½in wall pipe in under ten minutes.

[Reply Card No. E4664]



Transportable hydraulically-operated pipe bender for pipes up to 18in o.d. by ½in wall thickness

Transistorised Microvoltmeter

TRANSISTOR circuits operating from a self-contained battery supply give complete portability to the type TF1375 a.c. microvoltmeter of Marconi Instruments, Ltd., St. Albans, Herts. The instrument covers the range 5μV to 15V in twelve steps. Frequency range is 50 c/s to 1 Mc/s with switch-selected l.f. rejection. Basically, the instrument consists of a frequency-compensated input attenuator with decade steps, and a seven-transistor frequency-compensated amplifier having a voltage gain of approximately ×5000. Output from this amplifier is rectified in a full-wave bridge circuit before application to the meter ; in addition, the output from the penultimate stage is available at a front-panel outlet. The 4in meter has an overload-protected movement and includes a " check battery " facility.

Portable microvoltmeter with seven transistor amplifying stages available for alternative use as a pre-amplifier for other purposes

The TF 1375 can be used for a variety of purposes ; for example, as an oscilloscope pre-amplifier, as a sensitive measuring-bridge detector, or for field strength and aerial tests. In conjunction with a suitable pick-up loop, measurement can be made of leakage fluxemanating from mains transformers and electric motors. Its input impedance and sensitivity enable it to be used as a microammeter for detecting currents as low as 10^{-16}A.

[Reply Card No. E4665]

Steel for High Pressure and Stress Conditions

AN 18 per cent nickel alloy steel developed by the International Nickel Company, Inc., at Bayonne, N.J., U.S.A., is claimed to have exceptional properties making it particularly suitable for conditions of high pressure and stress. The steel has a nominal composition of 18 per cent nickel, 7 per cent cobalt, 5 per cent molybdenum, and less than 0·5 per cent titanium, with a maximum carbon content of 0·05 per cent. Higher and lower tensile strengths can be obtained by modifying this basic composition. There are indications that tensile strengths of up to 500,000 lb per square inch or even higher may be achieved. A 10-ton commercial billet has been produced by air melting in an arc furnace, and ingots as large as 23in by 42in have been rolled into plate by conventional equipment. The steel can be produced in all commercial shapes.

High strength, combined with remarkably good ductility and toughness, is developed by a simple heat-treatment involving age-hardening of martensite. This treatment has been given the name " mar-aging." With proper finishing temperatures off the mill, followed by air cooling to room temperature, the mar-aging treatment consists merely of holding for about three hours at 900 deg. Fah. and air cooling. Solution annealing at 1500 deg. Fah. prior to mar-aging is optional. Quenching is not necessary and the full properties of the steel can be developed in heavy sections without distortion.

Unusually low work-hardening tendencies permit of extensive cold working and shaping, and the machining properties of the material are excellent both as rolled and after heat-treatment. The steel can be welded readily by either manual or automatic methods, sound, crack-free welds being obtained without pre-heating. Post-weld mar-aging restores the softened, heat-affected zone of the parent metal to full strength and establishes in the weld-metal properties closely approaching those in the body of the material. The American company responsible for the steel is represented in Great Britain by the International Nickel Company (Mond), Ltd., Thames House, Millbank, London, S.W.1.

[Reply Card No. E4671]

Combine Drill

THE new " Lundell 300 " combine drill made by Lundell (Great Britain), Ltd., Edenbridge, Kent, was demonstrated on a farm in Kent last week. The thirteen-row unit, shown below, has two hoppers with capacities for 6 cwt of fertiliser and 3 cwt of grain, whilst the fifteen-row unit carries 7 cwt of fertiliser and 3½ cwt of grain. Four-inch hydraulic rams on either side of the drill are controlled from the tractor and allow the coulters to be raised out of work when turning. The drive to the seed and fertiliser runs is taken from the near-side land-wheel of the drill through gears and roller chain, and, as can be seen from the illustration, is automatically disengaged when the coulters are raised.

The flow of seed is controlled by manipulation of a lever set against a graduated quadrant on the front of the drill. This lever determines the position of a sliding fluted roller which is driven from the land wheel, and on to which grain is gravity fed. The roller force-feeds a predetermined amount of seed into the conductor tubes leading to the coulters. The amount of fertiliser delivered to the coulters is controlled by a lever on a quadrant mounted on the offside of the drill. The rate of delivery can be varied from 210 lb to 460 lb per acre. Inside the hopper, a " star wheel " delivery mechanism directs the fertiliser into the corrosion-resistant conductor tubes.

The coulters can be spaced at 7in, 10½in, 21in or 28in intervals, and their working depth is adjustable.

[Reply Card No. E4672]

The " Lundell 300 " drill

Technical Conditions for Nuclear Ships

BUREAU VERITAS has recently circulated a guidance note " General Technical Conditions for Nuclear Ships " which is intended to provide basic grounds for discussion between the shipyard and the registration society. The note is in four sections, namely general, limitation of the risks of incidents, limitation of accident consequences, and operation of the ship. Attention is drawn to the need to take into account the maximum ship's movement and corresponding accelerations related to rolling and pitching ; the cyclic vertical accelerations of heaving ; structure transmitted vibrations ; shocks ; ambient humidity and salinity, &c. There are notes upon classes of pressure vessels, the corrosion resistance of the material and the need for complete radiography of the welds. A calculation of thermal stresses is required. Two independent sets of steering gear are required as are also two coolant circuits for the reactors. As a protection against overpressures safety valves should be set to operate at 5 per cent excess, while control devices are divided into two categories, namely detective or service control and operative control. The note suggests that long slow-speed running should be possible and that the controls should ensure reactor start-up, initially and after shut-down, and reactor shut-down.

An emergency propulsive plant is required where there is one reactor and the fuel supply should enable the emergency machinery to have an endurance of 1000 miles. E.S.S. steel is to be used for the shell in way of the reactor compartment, which should have longitudinal boundary bulkheads set in not less than B/5 from the ship's side. With relation to the reactor coolant flow, an analysis is to be made of the consequences of various accidents. Another requirement is for an independent source of electric power which should be capable of operating with the ship listed to 30 deg. with 10 deg. of trim. For the containment vessel it is considered that the maximum stress due to the various imposed loads should not exceed 80 per cent of the yield stress. To meet eventualities such as sinking the corrosion resistance of apparatus in sea-water is to be evaluated and a system provided for equalising internal and external pressures on the containment vessel. There are notes on shielding, ventilation, defuelling and refuelling : with regard to radioactive wastes suitable storage having a reserve capacity of 50 per cent should be provided on board.

Industrial Television Camera

IN the design of the NEV " Eye " closed circuit television camera illustrated, every effort has been made to limit the price in order that this method of industrial supervision and control may prove economic for a wide range of users. The camera has been designed and developed by the Nottingham Electronic Valve Company, Ltd., East Bridgford, Notts. It is designed to operate into any standard domestic television receiver, its output being a composite modulated r.f. signal tunable to any channel in Band 1. Synchronising impulses and blanking impulses are derived within the camera and are mixed with the vision signal to form a composite wave-

Camera for closed circuit television into standard 405-line receivers

form which will lock any standard receiver working on the British 405-line system, or alternatively on the Continental 625-line system. The radio frequency output is approximately 10,000 microvolts into 75 ohms for peak white modulation. Power consumption is 50W.

The camera contains a standard 1in Vidicon tube of industrial grade. Only two valves are used in the circuitry, the other stages using one transistor, four silicon diodes and two germanium diodes. The horizontal generator is designed to be frequency-unstable, resulting in the line synchronisation pulses having a run-through characteristic relative to the frame synchronisation, giving results approximate to a fully interlaced picture.

Weight of the camera is 12 lb, and its measurements are 11½in by 5½in by 6¾in. It is fitted with a ⅜in tripod bush. The camera tube is equipped to carry a three-lens turret as shown in the illustration. A mixing and control unit for use with cameras of this series will be available at a later date.

[Reply Card No. E4674]

Finned Heating Elements

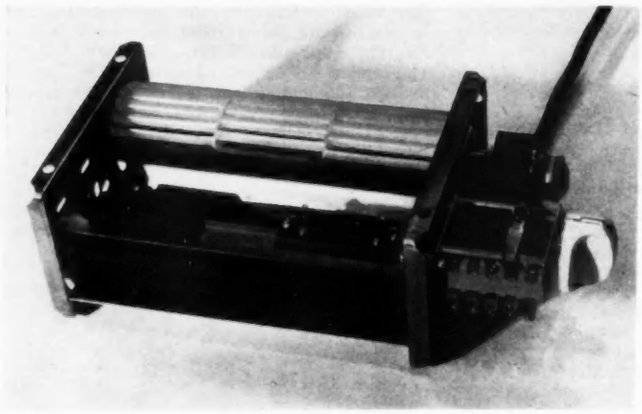
A FINNED electric heating element known as "Elfin", in which the fins are made from an "L" section and tightly coiled around the heating tube, has been introduced by Eltron (London), Ltd., Strathmore Road, Croydon, Surrey. The maker claims that the large area of contact between fin and heater results in a greatly increased transfer efficiency. The fins are also smooth and easily cleaned, having no pockets tending to collect water and dirt.

[Reply Card No. E4675]

SHORTER REPORTS *(Continued)*

Tangential Flow Fan Heater

We illustrate a prototype fan heater unit incorporating a Firth Cleveland fan manufactured and marketed under licence by the Accessories Division of the Solartron Electronic Group, Farnborough, Hampshire. The cylindrical plastic impeller, seen at the rear, is driven by a shaded-pole motor with two-speed control



Prototype fan heater with two-speed tangential flow impeller

by resistance, and the air is warmed by the edge-wound coil in the lower foreground. The coil can be switched off when the fan is required only for cooling. A rotary switch with cam-operated contacts, seen on the right of the illustration, selects the various modes of working. A thermal cut-out is provided.

The fan is based on a Continental tangential flow design. When the rotor is in motion a cylindrical vortex of air is set up inside it and is stabilised by a vortex former so that its centre is a very short distance from the inner edges of the rotor blades. The outer shell of the vortex couples with the input and output airstreams, which are pulled past the blades of the fan with higher velocity than the peripheral speed of the blades themselves. This principle, with its double traversal of the blades, provides high throughput per unit frontal area. A characteristic of the fan is its silent running due to the relatively low rotor speed and virtual freedom from turbulence in the outgoing air stream. Two results of the speed of the stream are a throw of some 15ft before it is broken up by convection, and the ability to use a powerful heater in a small unit without raising the temperature of the output air to an uncomfortable level. The rating of the prototype is 2kW, and the output is controlled by the motor speed, the lower speed giving warm air at quarter power. It is proposed by the maker to use the same principle in table fans, convectors, cooling units for electrical and electronic equipment (including hermetically-sealed devices), semiconductor power rectifiers, refrigerators and cold stores, and for forced cooling of air-cooled engines. A further step foreseen is the building-in of fan-heaters in houses, enabling heating to be provided by fans about the size and shape of fluorescent tubes.

[Reply Card No. E4681]

Rack-Mounting Oscilloscope

We illustrate a rack-mounting, double-beam oscilloscope introduced by Solartron Laboratory Instruments, Ltd., Cox Lane, Chessington, Surrey. The instrument has two identical Y amplifiers, bandwidth d.c. to 5 Mc/s (−3 dB), with a rise time of approximately 70 μsec. Nine calibrated sensitivity ranges, switched in 1–2–5 sequence, cover 100 mV/cm to 50 V/cm with ±5 per cent accuracy. In addition, a fine control gives continuous coverage up to approximately 100 V/cm. An integral a.c. preamplifier preceding Y^2 gives six additional sensitivity ranges with a maximum sensitivity of 1 mV/cm. The input impedance is 1MΩ and 30 pF. Inputs may be "floated" up to ±500V relative to chassis for displaying signals isolated from earth.

The "bootstrap" timebase covers 1 cm/μsec to 2 cm/sec in eighteen calibrated ranges and a maximum sweep speed of 5 cm/μsec may be obtained by using X expansion. The timebase waveform (10V peak-to-peak) is available at a socket on the front panel. The X amplifier (bandwidth d.c.—750 kc/s) has a continuously variable sensitivity from 0·15V/cm to 1·5V/cm. Direct access to this amplifier is available for external signals.

[Reply Card No. E4682.]

Liverpool Steam Ship Owners' Association

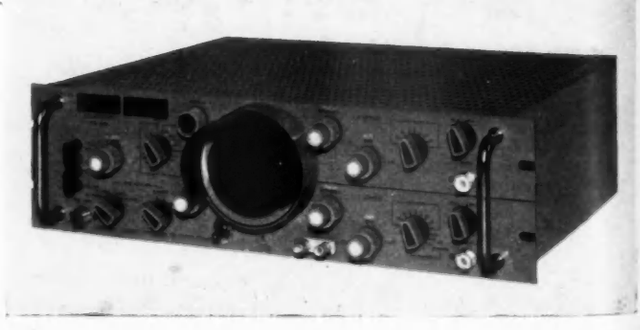
The report of the Liverpool Steam Ship Owners' Association for 1960 records that the tonnage entered in the Association totalled 4,043,834 tons gross at the beginning of 1961 and that imports increased by 14·5 per cent over 1959 and reached a total of 128·2 million tons, while their value increased by 13·6 per cent to £4556 million. Tonnage entrance returns show that the share of British ships was only 49 per cent compared with 51 per cent in 1959 and 56·9 per cent in 1938. Exports from the United Kingdom are given in the report as 25,658,000 tons, representing an increase of 2·6 per cent over the previous year while their value rose by 6·4 per cent to £3677 million. Of the tonnage clearances the British percentage was 60 per cent compared with 61 per cent in 1959. The survey by the General Council of British Shipping is referred to, and the report reiterates the need for Government countermeasures against nationalistic policies of foreign governments, policies which are having a gravely eroding effect upon British shipping and which cannot be overcome by efficiency and enterprise. Once again the Association points out that taxable profits do not arise until provision has been made for fleet renewals, and that neither ships nor ports will operate efficiently under conditions influenced by artificial aids framed to favour particular countries. Various causes have created the situation where shipping is in excess of demand; nevertheless the spread of discrimination must be discouraged first by persuasion but, failing that, by counter measures which will regrettably end in one way traffic. Another point mentioned is that the main value of a subsidy is to save a British shipping service which may have its survival threatened by unfair competition. Furthermore the report canvasses for the removal of the anomaly in the law which prevents British shipping from taking advantage of tax relief from facilities within the Commonwealth while allowing competitors to do so.

Compression of Double-Bottom Plating

On March 17, T. Jaroszynski, B.Sc., presented a paper entitled "Experiments in Compression of Double-Bottom Plating" before the North East Coast Institution of Engineers and Shipbuilders. The paper, which we summarise, describes experiments carried out by Lloyd's Register of Shipping for the British Shipbuilding Research Association on an Amsler horizontal testing machine of 1200 tons capacity in the works of Dorman Long and Co., Ltd. Welded and riveted box-shaped structures resembling the double-bottom of a ship were subjected to a compressive load in order to ascertain the behaviour of a panel of plating and to determine its load-carrying capacity. The effect of reinforcing a panel, which had already sustained some permanent deformation, by different intercostal stiffeners is described. Diagrams show the initial form and deflection and stress set up in the plating under compression, and the difference in the behaviour and the load-carrying capacity of a riveted and welded panel is discussed. The efficiency of some of the welded and riveted panels tested is determined and compared with theoretical calculations, while the effect of successive applications of load to a panel with initial deflection is also shown. It is concluded that the experiments demonstrated the effect of panel size upon load-carrying capacity and the effectiveness of intercostal stiffeners in restoring efficiency. To obtain full benefit from welded construction subjected to higher compressive stress the panels should be stiffened longitudinally. Another conclusion is that the restraint offered to a panel by boundary supports is greater in the welded than in the riveted specimens. Furthermore, even when yield point has been reached, and provided the rest of the structure remains elastic, a welded panel can withstand considerable deformation and recover its original form.

Flow Controller

A device for controlling the flow of liquid through a pipeline at a constant preset rate, irrespective of pressure fluctuations, has been introduced by the Permutit Company, Ltd. This controller, called the "Pervo," is available in straight-through or angled models and in a



Double-beam oscilloscope for rack mounting. Panel dimensions are 5¼in by 19in, and the depth behind front panel is 13in

number of standard sizes. Its rate setting can be by direct manual, remote manual or fully automatic control, and a slow start attachment can be provided for filter applications. The standard controllers available are suitable for flows varying in the ratio of one to four and, it is stated, accurate control is obtained throughout the whole of this range.

The main components of the controller are a venturi section, a pair of linked and balanced valve gates downstream of the venturi throat,

Controller for flows varying in the ratio of 1 to 4

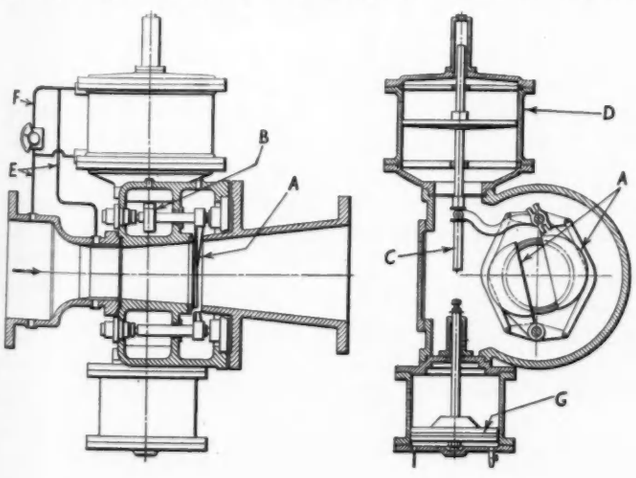
and an actuating mechanism. Its operation can be followed from the diagram which shows the controller in simplified form.

The valve gates *A* are operated by a lever *B* having attached to its free end a roller, which engages with collars fitted to the piston rod *C*. This rod, guided by bushes, carries a piston inside the actuating cylinder *D*, a clearance between piston and cylinder barrel being provided to prevent friction.

Connecting pipes *E* lead from the upstream and throat tappings of the venturi to the bottom and top of the actuating cylinder to transmit differential pressure created during flow through the venturi to the piston in the cylinder. The connecting pipes are coupled by a by-pass *F*, fitted with an adjustable rate-setting valve. This valve produces a predetermined differential acros the piston that remains constant, irrespective of change in differential in the venturi caused by variations in flow. The weight of the piston and its associated moving parts is balanced by the upward thrust created by the differential across the piston.

With no flow through the venturi there is no differential and the piston remains at the bottom of its stroke—the valve gates are then fully open. When flow starts a differential created in the venturi is transmitted to the actuating cylinder and the piston is forced upwards, causing the valve gates partially to close. Flow through the venturi is thus throttled and a state of equilibrium is reached as determined by the rate-setting valve. If the flow tends to drop, the differential in the venturi is reduced. The piston consequently falls causing the valve gates to open and flow is again restored to the preset rate. An automatic slow start mechanism which can be provided consists essentially of an auxiliary cylinder and piston vertically opposed to the main actuating cylinder. With this auxiliary device when pressure water is admitted to the lower end of the cylinder the piston *G* rises and locks the actuating piston in the upper position —the valve gates are thereby closed and flow stops. Pressure in the auxiliary cylinder is then exhausted at a predetermined rate through an adjustable bleed, allowing the valve gates to open slowly until normal load conditions are restored.

[Reply Card No. E4685]



Diagrammatic arrangement of flow controller fitted with slow start mechanism

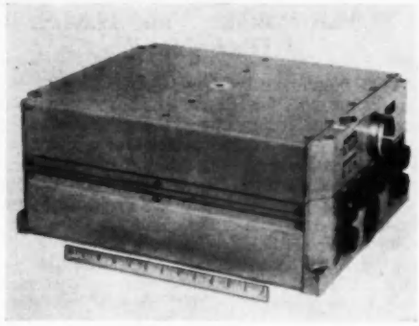
Computer for Guidance Systems

AGREEMENTS have been entered into between the Autonetics Division of North American Aviation Inc. and Elliott Brothers (London), Ltd., Elstree Way, Boreham Wood, Herts, for the manufacture and sale in the United Kingdom of the "Verdan" digital computer. Three of these computers are used in connection with different systems in the submarines carrying the "Polaris" missile, and there are other installations in missiles and aircraft. The computer as illustrated measures 15⅝in by 8in by 19 $\frac{9}{16}$in and weighs approximately 82 lb. Power consumption is approximately 320W on a 400 c/s supply. The unit is arranged for connection to an external source of cooling air by means of the inlet and exhaust ports at the right-hand end of the case. A small plenum chamber inside the inlet distributes the air-flow in various proportions according to the cooling required by different sections of the computer. Parts of the magnetic disc information store adjacent to the motor are finned to improve heat dissipation.

The computer circuits use semiconductors throughout and consist of plug-in printed-circuit modules with components on both sides, the plating being continuous through the holes in the boards. There are ninety-six of these boards, and the computer contains 10,000 diodes and 1500 transistors. These components are all of well-proved forms made and tested to North American Aviation specifications by various firms under the supervision of teams representing the computer manufacturer.

The computer comprises a general-purpose section, a digital differential analyser for incremental computation, and an input-output section for communicating directly with other portions of complex systems. A characteristic feature is the magnetic disc store, which is driven by a 400 c/s synchronous motor at 6000 r.p.m. The head-to-disc gap is set by an air bearing depending on a boundary layer phenomenon, the force of separation being a function of the viscous shear of the air in the gap. A further feature of the computer is that if power is interrupted anywhere in the course of a computation, stored information is retained indefinitely, or until power is restored and the computation resumed. Storage capacity of the disc is 1666 words in thirteen channels.

As a navigational aid, particularly in supersonic aircraft, the "Verdan" computer would receive inputs from inertial guidance and



Transistorised digital computer for airborne and submarine navigational systems

Doppler systems and its outputs could be displayed to the crew or fed in the form of demand signals into a flight control system. Continuous calculations of arrival time and fuel calculations could also be performed.

[Reply Card No. E4692]

Regional Technical Colleges

THE list of Regional Technical Colleges in England and Wales is to be revised and a new list designated. In a circular to local education authorities dated Wednesday, March 15, Sir David Eccles, Minister of Education, explains that up to April, 1959, regional colleges were, in effect, identified with those colleges receiving a special grant for courses in advanced technology. This test is no longer applicable, says the Minister, and it is necessary to review the list of regional colleges and to decide how far it continues to be appropriate in view of recent and prospective developments at the individual colleges and in the regions generally.

There are four types of technical colleges—Colleges of Advanced Technology, Regional Colleges, Area Colleges and Local Colleges. The nine Colleges of Advanced Technology are being developed as centres for work exclusively at university level, including post-graduate work and research. Between these colleges, at the apex of the educational system, and the 300 local colleges, there are nearly 200 colleges doing a greater or less amount of advanced work. About twenty of them are at present known as Regional Colleges, the rest being Area Colleges.

Regional Colleges have been envisaged for some years as the establishments to which—after the Colleges of Advanced Technology—industry would look for the development of new advanced full-time and sandwich courses in applied science and technology. The circular says if advanced work is to be efficiently organised, and particularly if scarce staff and equipment are to be used to the best advantage, regional, and in some cases national, planning is essential. It is contemplated that in some regions there will continue, as at present, to be a need for more than one regional college. But there may be cases in which it will be necessary to choose between colleges, taking account of geographical and other factors. Geographical considerations alone will not entitle a college to regional college status, says the circular. No college will be designated unless the Minister is satisfied that it is capable of discharging its functions adequately, including the provision of a sufficient volume of advanced work, with adequate staff and governing arrangements and suitable premises.

Decisions on the colleges to be designated in the revised list will be taken after consultations with local education authorities and the regional advisory councils. It is not the Minister's intention to fix now for all time the list of regional colleges. The list will be revised again in the future if at any time it appears desirable in view of changed circumstances.

Colleges of art or colleges of commerce will not be affected.

SHORTER REPORTS *(Continued)*

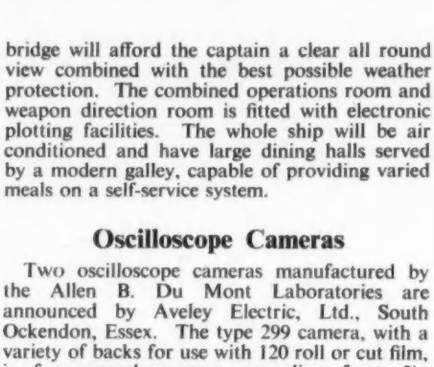
H.M.S "Blake" and H.M.S. "Hampshire"

Two new warships have figured in the news during the past few days. H.M.S. "Blake," a cruiser, the third of the "Tiger" class to be completed, was commissioned for service on March 8 at Fairfield Shipbuilding and Engineering Company's yard, Govan. Just over a week later, on March 16, H.M.S. "Hampshire"—the second ship of the "Devonshire" class—was launched by H.R.H. Princess Margaret at the shipyard of John Brown and Co., Clydebank. The "Blake" will probably be the last new ship to be commissioned for the Royal Navy armed with a conventional heavy armament of 6in guns. As in the case of the 15in gun battleship, the 6in gun cruiser is no longer required to safeguard the trade routes against surface ship attack, a task now to be left to carrier borne aircraft and to the new type of destroyer—the "Devonshire" class—armed with anti-aircraft guided missiles and 4·5in guns. Like her two sister ships—the "Tiger" and "Lion"—H.M.S. "Blake" was laid down during the war. Launched in December, 1945, work on her was suspended until 1954 when it was decided to complete the three ships and equip them with newly developed fully automatic 6in guns of a very advanced design. Her main armament now consists of four 6in guns mounted in two twin turrets, which are equally effective in the surface-to-surface and anti-aircraft rôles. Their rate of fire is twenty rounds per minute, which is more than twice as fast as that of any other cruiser's main armament. The secondary armament consists of six 3in guns mounted in three twin turrets. These guns are capable of 120 rounds per minute—a rate of fire comparable with the light A.A. guns of World War II. She is fitted with a comprehensive gun direction system which enables each turret to be controlled by radar. H.M.S. "Blake's" main machinery is largely automatic and can be remotely controlled. It consists of four geared steam turbines which take their power from four Admiralty design boilers, and produces a total of 75,500 s.h.p., giving a top speed of over 30 knots. The ship has a length of 555ft 6in, a beam of 64ft and displaces 9500 tons. Complete air conditioning has been installed so as to ensure a comfortable atmosphere in any climate ; and to make the running of the ship pleasant and easy, a large amount of electric equipment has been provided for cooking, deck cleaning and paint-scaling, together with television, cinema and radio rediffusion installations. To keep all this and other equipment working, four turbo-generators provide 4000kW of alternating current, the first time this type of power has been used in British cruisers. A 200 line automatic telephone exchange takes care of internal communications.

H.M.S. "Hampshire" was laid down in March, 1959, and is expected to join her sister ship, the "Devonshire," in the Fleet in 1962. With a standard displacement of over 5000 tons, an overall length of 520ft and a beam of 54ft the "Hampshire" will carry : one "Seaslug" guided weapons system ; four radar controlled 4·5in guns in twin mountings situated forward; and two "Seacat" close range guided weapons systems fitted abaft the after funnel. For anti-submarine work the ship will be fitted with the latest underwater detection equipment and a Westland "Wessex" helicopter carrying dipping asdic and homing torpedoes. The propulsion machinery consists of two sets of geared steam turbines for normal steaming conditions, with gas turbines to provide additional boost for high speed and for getting quickly under-way in harbour. The steam turbines were manufactured by John Brown and Co., Clydebank, and the gas turbines by Yarrow and Co., Ltd., and J. S. White and Co., Ltd. Stabilisers will be fitted which, among other uses, will facilitate the operation of the helicopter in adverse weather conditions. The "Hampshire" will have the latest air and surface warning radars. Her bridge will afford the captain a clear all round view combined with the best possible weather protection. The combined operations room and weapon direction room is fitted with electronic plotting facilities. The whole ship will be air conditioned and have large dining halls served by a modern galley, capable of providing varied meals on a self-service system.

Oscilloscope Cameras

Two oscilloscope cameras manufactured by the Allen B. Du Mont Laboratories are announced by Aveley Electric, Ltd., South Ockendon, Essex. The type 299 camera, with a variety of backs for use with 120 roll or cut film, is for general purpose recording from 5in oscilloscopes. We illustrate the type 302 camera



Oscilloscope camera with Polaroid back

with Polaroid back for records on transparent or opaque film. Both instruments incorporate means for adjustment so that more than one trace can be recorded on a frame. Detent stops position the camera backs for equally spaced exposures, whilst a scale and pointer arrangement assists in positioning the back accurately for more than three exposures per frame. Facilities for data recording are also provided. The choice of lens available is the Woollensac Du Mont 75mm f2.8 three-element lens, or a 75mm f1.9 six-element lens. Two bezel adaptors enable the cameras to be used with almost all 5in tube oscilloscopes.

[Reply Card No. E4702]

Vacuum Metallising

A CONTINUOUS vacuum metalliser for a wide variety of materials supplied in the form of rolls 12in diameter by 12in wide is now supplied by Vacuum Metallurgical Developments, Ltd., Shelford, Cambridge, as a self-contained machine ready for operation upon connection to the normal services. The maker states that in this equipment, illustrated herewith, the ability to coat base material without previously drying has been extended to certain grades of vegetable parchment, and nearly all known plastic films can be metallised as received from the supplier.

Vacuum metallising equipment taking material in rolls 12in diameter by 12in wide

When the material has been mounted in the machine the vacuum chamber is closed and pumped down in a period of about two minutes. The web first passes over a heated continuous evaporation source and is then rewound in the main chamber of the machine. Air is admitted in less than a minute after coating and the finished roll can be removed. It is claimed that a production of more than 25,000 linear feet per hour of material can be readily attained.

This equipment has been designed specifically for capacitor requirements and with it plastic film or capacitor tissue can be metallised in one operation and provided with a blank margin, slit, and rewound on to bobbins suitable for the direct winding of capacitors. Film resistances of the order of 1½ ohm/sq. are said to be readily achieved, and rewinding and marginating carried out to tolerances of better than ±0·2mm.

[Reply Card No. E4703]

Travelling Exhibition of Sound Equipment

DEVELOPMENTS in audio apparatus of many kinds are represented in a touring exhibition, "Emifair," which has been arranged by Electric and Musical Industries, Ltd., Hayes, Middlesex, and is visiting towns in England, Wales and Scotland. Among aids to hearing which are being demonstrated are Ardente plastic "Selectones" for insertion in the ears to suppress unwanted frequencies. These are available in two patterns for use where it is necessary to listen to voices and the telephone, and where higher noise levels make comfort the first consideration. Advice on noise control and hearing conservation by this and other means is provided by the Ardente Industrial Service, 100, Wigmore Street, London, W.1. Examples of amplification as aids to hearing include an electronic stethoscope operated off a 4V mercury cell, which is as light and convenient for use by the general practitioner as the ordinary stethoscope. A new item among tape recording equipment is the RE321, a transistorised version of the L2B which weighs 16½ lb and takes its power for all purposes from eight U2 batteries (12V). This uses an E.M.I. motor designed at Hayes with centrifugal governor acting on the field circuit.

[Reply Card No. E4704]

Launches and Trial Trips

BORDER PELE, oil tanker ; built at Wallsend yard of Swan, Hunter and Wigham Richardson, Ltd., for The Lowland Tanker Company, Ltd.; length between perpendiculars 535ft, breadth moulded 72ft 6in, depth moulded 41ft, deadweight 19,610 tons on 31ft 7in draught, loaded service speed 13¾ knots ; twenty-seven cargo tanks, one main pump room, three 500 tons per hour cargo pumps ; three 260kW diesel-driven alternators, two multi-tubular boilers, Wallsend-Doxford two-stroke opposed piston, diaphragm pattern, oil engine, six cylinders, 700mm bore, 7200 b.h.p. at 115 r.p.m. Trial, January 27.

BAMORA, cargo liner ; built at Govan by Harland and Wolff, Ltd., for the British India Steam Navigation Company, Ltd.; length between perpendiculars 395ft, breadth moulded 59ft, depth moulded to upper deck 32ft 6in, deadweight 7500 tons, speed 16 knots ; four cargo holds, five electric deck cranes, four 10-ton derricks, electric cargo winches ; four 350kW diesel-driven alternators, 440V, 60 c/s ; Harland and Wolff two-stroke, single-acting, opposed piston oil engine, six cylinders, 620mm bore by 1870mm combined stroke, 118 r.p.m. Trial, January 30.

CUSTODIAN, cargo ship ; built by William Doxford and Sons (Shipbuilders), Ltd. for the Charente Steam Ship Company, Ltd.; length overall 488ft 2in, breadth moulded 62ft, depth moulded 38ft 9in, deadweight 10,920 tons, service speed 16 knots ; derrick complement includes one to lift 110 tons ; Doxford oil engine, six cylinders, 650mm bore by 2320mm combined stroke. Trial, February 16.

INDUSTRIAL NEWS

Youth Employment in Scotland

Mr. John Hare, Minister of Labour, speaking in Glasgow last week at a conference organised by the Industrial Training Council to consider problems of youth employment arising from the increasing numbers of school leavers in the next two years, said that a number of meetings were being held all over Great Britain during the next few weeks to discuss how to ensure that the extra boys and girls now about to enter industry were given the employment and training necessary for the good of themselves and for industry. The "bulge" in Scotland, he pointed out, was more concentrated into the two years—this year and next year—than in England and Wales. Last year in Scotland 62,000 young people left school and came on the employment market. This year 75,000 are expected, an increase of 21 per cent. Next year the number would be 81,000, 31 per cent more than in 1959.

Since the war, Mr. Hare continued, Scotland's rate of unemployment had been substantially higher than those of England and Wales. The need for diversification of industry had been recognised by the Government, he added, and since 1945, 115,000 jobs had been created in new industry in Scotland, most of them in recent years and about half in factory buildings financed by the Government. The year 1960 was one of Scotland's most successful years for the introduction of new industrial projects and for the consolidation and expansion of projects already begun. No less than 30,000 new jobs are expected to be provided from developments now under construction, approved, or likely to go ahead.

Mr. Hare went on to urge Scottish employers to take the opportunity which the "bulge" gives them to broaden their base of skilled labour. One of the main attractions to expanding industry of the less buoyant employment areas will disappear, he said, if incoming firms find themselves facing the same shortages of skilled labour which they have already experienced in other parts of Great Britain.

The Industrial Training Council and the committee responsible for organising the Scottish conference were considering establishing for Scotland on a continuing basis a committee, on which both sides of industry would be represented, which would keep a close eye on the employment and training situation for young people during the next critical years and which would constantly explore the needs and possibilities of action. Mr. Hare said that he would welcome the establishment of such a body, and that his Ministry would willingly give it any secretarial and other assistance which might help in its task.

New Orders for Construction Work

According to the latest figures issued by the Ministry of Works, orders to the value of £473 million were obtained by contractors in the construction industries in the fourth quarter of 1960. This equals the figure reached in the first quarter of 1960, the highest since the series was started in 1956. Taking the year as a whole, the Ministry says, the value of new orders obtained in 1960 was £1842 million which was £256 million more than in 1959, while the value of new work carried out by contractors in 1960 was only £140 million more than in 1959. It must be expected, therefore, the Ministry suggests, that the level of activity during 1961 will remain high.

Orders for public authority housing were virtually the same as for 1959, but orders for houses for private developers increased by over £40,000,000. The total value of work done on housing increased by over £60,000,000 compared with the previous year, the Ministry says, so that the amount of work outstanding on housing has decreased.

Coal Prices

The Industrial Coal Consumers' Council submitted a report to the Minister of Power in February on the representations made to it on behalf of the Federation of British Industries, the British Iron and Steel Federation and the Joint Iron Council about last September's increases in the National Coal Board's prices for coal and on the Board's replies to these representations. The representations covered the shortness of the notice given by the Board of its intention to raise prices, the reasons for the Board's need for additional revenue, the sharing of the burden between different types of consumer, and the effect of the increased prices on industrial consumers, on the British economy generally and on the coal industry itself.

In his reply to the Industrial Coal Consumers' Council Mr. Richard Wood, Minister of Power, said that the report suggested that the main consultations were between the Board and the Ministry, and the Council was informed of the proposals only at a late stage. Both the Council and the Government have accepted, Mr. Wood said, that the change in its market conditions justified the industry in adopting a more flexible approach to pricing, and it can be argued, he added, that it should be given no less freedom to fix prices than its competitors. He did not think, however, that something as important as the price of coal could cease to be one of the matters of major policy that were a proper subject of consultation between the Chairman of the Board and the Minister. Mr. Wood went on to say that he appreciated the Council's feeling that the length of notice given last September was inadequate and he was sorry that in the circumstances at that time longer notice could not be given. The Board had assured the Council that it would try to give longer notice in future.

Mr. Wood noted, in his reply, that, on the information available to it, the Council did not wish to question further the need for raising prices so as to produce an increase of £60,000,000 in annual revenue. Commenting on the question in the report as to whether the price increases were consistent with the Board's duty "to further the public interest in all respects," Mr. Wood said that he felt that the consequences for the nation of further substantial increases in the coal industry's accumulated deficit would have been even more serious than the consequences of increased prices.

The report next drew particular attention to the change in the price of coal used by the iron and steel industry in relation to that used by the gas industry, and to the change in the price of large coal. If the Board is to exercise a reasonable degree of commercial freedom, Mr. Wood replied, it must attempt to take into account not only the costs attributable to the winning of particular grades of coal but also conditions in the market and the availability and price of competing fuels. The fixing of prices, he added, involved a commercial judgment of the effect of various factors, some of which could not be stated in quantitative terms.

Guide to Careers

The National Union of Teachers has this week published the 1961 edition of its annual guide to careers. In the introduction to the guide Sir Ronald Gould, general secretary of the National Union of Teachers, states that in view of the organisation of Commonwealth Training Week—May 29 to June 4—the bulk of the editorial content of this year's guide is devoted to aspects of training and apprenticeship.

A series of articles written by young people entitled "What is it Like?" covers computing, banking, the Post Office, industry, the Civil Service, electricity supply, catering and retailing. The "Importance of Training for a Career" is explained by Mr. John Marsh, secretary of the Industrial Welfare Society, "Full-time Vocational Training" is dealt with by Mr. Tudor David, and there is an article on "Training Schemes for Girls" by Miss K. M. Allsop. Other articles in the guide deal with co-operation between schools and the Youth Employment Service, vocational guidance, the parents' role, the work of the Industrial Training Council, apprenticeship schemes to-day, provision for the non-apprentice, and new developments in apprenticeship and allied fields. The guide also contains a great many employers' notices giving details of education and training schemes.

Industrial Derating and Shipbuilding

A statement made by Mr. C. R. Connell, a director of Charles Connell and Co., Ltd., points out that the increase in the rateable value of the company's shipyard will, even allowing for a reduction in the rates, add £20,000 to the annual costs, a figure which will be more than doubled if derating is abolished. When the 10 per cent increase in electricity charges is added to the additional rates the effect will be to add £10,000 to the hull of a new tramp ship, to which must be added proportionate increases for equipment and main machinery since the hull only accounts for 40 per cent of the total cost. Furthermore when the reduction in working hours and a pay increase is taken into account together with the increase in the employers' National Insurance contributions the additional cost of a cargo ship's hull will be £30,000.

Recently booked contracts, the statement points out, were taken at fixed prices which do not include the increased charges so that losses will be involved. Such increases in costs coming at a time when every effort is being made to be competitive and when financial aid is being given to competitors abroad are adding to the industries difficulties. It is significant that not one of the fifty shipbuilding contracts placed recently by Norway has been booked by a British shipyard.

PERSONAL AND BUSINESS

Appointments

MR. D. C. M. SALT has been appointed a member of the board of Monsanto Chemicals, Ltd.

MR. ARTHUR DITCHER has been appointed manager of the surface division of Richard Sutcliffe, Ltd.

MR. MICHAEL J. PLEETH has been appointed marketing manager of Brush Crystal Company, Ltd.

MR. ROY W. ELVIDGE has been appointed sales manager of Solartron Laboratory Instruments, Ltd.

MR. J. E. YATES has been appointed to the board of Lancashire Dynamo and Crypto, a company in the Metal Industries Group.

MR. PETER J. WRIGHT has joined the marketing division of Massey-Ferguson (United Kingdom), Ltd., Coventry, as general sales manager.

AIRCRAFT-MARINE PRODUCTS (GREAT BRITAIN), Ltd., states that as from March 27 the area sales engineer for the south-west of England will be Mr. J. H. Munns.

MR. R. S. EASBY is to join Sino-British (Hong Kong), Ltd., on May 1, as director in charge of the Tokyo branch and assistant director to the chairman, Mr. John B. Macmillan.

MR. C. ST. C. PROCTOR has been appointed to the board of S. Smith and Sons (England), Ltd., as financial director. Major C. M. Carrington has retired from the board.

MR. JOHN EVERED has been appointed manager of the Newcastle branch of IBM United Kingdom, Ltd. He replaces Mr. K. Woodard who has become country manager of IBM service bureaux.

WOLF ELECTRIC TOOLS, Ltd., states that Mr. J. O. Bovill has been appointed managing director of its associated company Wolf Sales Pty., Ltd., Arthur Street, Homebush, Nr. Sydney, New South Wales.

THE MINISTRY OF AVIATION announces that Mr. A. H. Milward has been re-appointed as a member of the board of the British European Airways Corporation for a period of five years to April 30, 1966.

BTR INDUSTRIES, Ltd., announces the appointment of Mr. J. Lewin, A.M.I.C.E., A.M.I.Mech.E., as materials handling engineer responsible for the development of mechanical handling techniques within the BTR Group.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., announces that Mr. J. Varley and Mr. G. H. Parr, refinery manager and sales manager respectively of British Copper Refiners, Ltd., have been appointed directors of that company.

THE NORTH BRITISH RUBBER COMPANY, Ltd., announces the appointment of Mr. A. F. Rose as field sales engineer—wire braid hose. He succeeds Mr. T. S. Martin who has taken up an appointment with Stratoflex (U.K.), Ltd.

MR. J. A. FORD, home sales manager of Renold Chains, Ltd., has been appointed sales director of Renold Chains (Sales) Australia Pty., Ltd., and will be leaving for Australia in June. Mr. F. T. Stanford will succeed Mr. Ford as home sales manager and Mr. A. E. Clough has been appointed commercial sales manager (home) in succession to Mr. Stanford.

THE METAL INDUSTRIES GROUP announces that Mr. John Black, the deputy chairman, has been appointed, in addition, managing director, and Mr. Wilfred Padley becomes deputy managing director.

MR. H. H. WOOLVERIDGE, a director of The Distillers Company, Ltd., has been elected President of the British Plastics Federation in succession to Mr. C. H. Glassey.

MR. ANTHONY M. BROWNE, chairman and managing director of Hackbridge and Hewittic Electric Company, Ltd., and chairman of Combined Electrical Manufacturers, Ltd., has been elected President of the British Electrical and Allied Manufacturers' Association. Mr. H. H. Mullens, M.I.E.E., chairman and managing director of A. Reyrolle and Co., Ltd., and chairman of C. A. Parsons and Co., Ltd., has been elected deputy president.

THE UNITED STEEL COMPANIES, Ltd., has announced the following appointments in the commercial department of Appleby-Frodingham Steel Company : Mr. R. G. Smith has been appointed assistant commercial manager, Mr. C. R. Bennett has been appointed sales manager (heavy products) and Mr. I. E. Stewart has been appointed sales manager (light products). In addition, Mr. C. A. Griffin has been appointed raw materials officer and Mr. I. W. Pettinger will succeed Mr. L. E. Jackson as head of quotation section (heavy products) on the latter's retirement at the end of June.

LONDON TRANSPORT has announced that Mr. P. R. Silverlock has been appointed principal executive assistant in the running division of the department of the chief mechanical engineer (railways) with the title of divisional engineer " B."

Business Announcements

MR. H. J. T. PAIGE, assistant estate and rating surveyor (Scotland), British Transport Commission has retired after forty-eight years' service.

PRITCHETT & GOLD AND E.P.S. COMPANY, Ltd., manufacturers of Dagenite batteries, has transferred its Birmingham depot to 234, Stratford Road, Shirley, Solihull, Warwicks (telephone Shirley 6661-2).

MR. E. S. COX, assistant chief mechanical engineer of the British Transport Commission, has left on a three-weeks tour of South Africa, Southern Rhodesia and East Africa to lecture on British Railways' experience with diesel and electric traction.

JAMES ARCHDALE AND CO., Ltd., a member company of the Staveley Group, states that after March 31, its sole address will be Blackpole Works, Worcester (telephone Worcester 27081). The company's premises at Ledsam Street, Birmingham, will be closed on that date.

BRUSH CRYSTAL COMPANY, Ltd., Hythe, Southampton, Hants, announces that as a result of the recent acquisition of Shockley Transistor by the Clevite Corporation, Cleveland, Ohio, the Brush Crystal Company, an associate of Clevite, has been appointed exclusively to handle the Shockley four-layer diode in the United Kingdom.

GEORGE H. ALEXANDER MACHINERY, Ltd., 82, Coleshill Street, Birmingham, 4, states that the agency it holds at present covering Ajax-Hogue wire drawing attachments for cold headers, has been extended by its principals, The Ajax Manufacturing Company, Cleveland, Ohio, U.S.A., to cover its range of continuous drawing and straightening machines and intermittent drawing, straightening and cut off machines, in the United Kingdom.

CONVEYANCER FORK TRUCKS, Ltd., Liverpool Road, Warrington, and The RAYMOND CORPORATION, Greene, N.Y., are forming a company, Conveyancer-Raymond, Ltd., to manufacture and distribute in the United Kingdom and other markets the Raymond range of reach, straddle and pallet trucks, and other Raymond narrow aisle equipment. The new company will be an associate of Electro-Hydraulics, Ltd., which is a subsidiary of Rubery Owen and Co., Ltd., Darlaston. The board of directors will be as follows : Mr. A. G. B. Owen, chairman ; Mr. C. W. Sharp, managing director ; Mr. George G. Raymond and Mr. L. Rumley.

G. AND J. WEIR HOLDINGS, Ltd., which presently owns 50 per cent of the issued share capital of Weir-Catton, Ltd., announces that it has made arrangements to acquire the remaining shares of that Company. Weir-Catton, Ltd. is a holding company with two operating subsidiary companies, Catton and Co., Ltd., Leeds, and Weir Foundries, Ltd., Leeds, which manufacture quality castings in carbon, low alloy and stainless steels.

MR. STERLING COLE, director general of the International Atomic Energy Agency, and MR. GUNNAR RANDERS, managing director of the Norwegian Institute for Atomic Energy, announced to-day the selection of Dr. Raja Ramanna of India to be chairman of the management committee which will determine the joint research programme in reactor physics utilising Norway's zero power reactor, " Nora."

CRANES (DEREHAM), Ltd., South Green Works, Dereham, Norfolk, announces that, with participation by the Wall Engineering Company, a private company, it has entered into negotiations with Fruehauf International, a subsidiary of Fruehauf Trailer Company of Detroit, Michigan, U.S.A., to form a new company at North Walsham to manufacture trailers and semi-trailers embodying designs and specifications of both Fruehauf and Cranes.

MR. JOHN BROWN, managing director of Aveley Electric, Ltd., left London during the middle of March for a fourteen-day business trip to Canada and America. He will investigate the market for a number of toroidal products the company is now introducing, d.c.-d.c. converters, a.c.-d.c. inverters and audio transformers. He will also visit the company's American principals, including Allen B. Du Mont Laboratories, Fairchilds Camera Corporation, Stoddart Aircraft Radio Corporation and Dynaco Inc.

KESTNER EVAPORATOR AND ENGINEERING COMPANY, Ltd., has licensed Dicon, S.A. de C.V., at Avenida Popocatepetl 26-302, Mexico City, D.F. to manufacture many of its chemical engineering equipment items, including chemical evaporators, crystallisers, driers, and acid proof equipment, on a " Made in Mexico " basis. A licence has also been granted by Richard M. Armstrong Company, West Chester, Pennsylvania, U.S.A. to Dicon to manufacture Armstrong heat transfer equipment in Mexico. This includes shell and tube exchangers for chemical and petroleum plants, air cooled heat exchangers, vaporisers and refrigeration shell and tube apparatus, including scraped shell heat exchangers for petroleum refining.

MR. JOHN THORNYCROFT, MR. G. E. T. EYSTON, MR. ROGER THORNYCROFT, and MR. I. DONALDSON have resigned from the board of Transport Equipment (Thornycroft), Ltd., following the acquisition of the whole of the share capital by Associated Commercial Vehicles, Ltd. Mr. R. J. Newman will continue as managing director, and Sir William Black, managing director of Associated Commercial Vehicles, Ltd., and chairman of A.E.C., Ltd., has been appointed chairman of the company. Mr. J. O. Bowley, director and general manager, and Mr. J. D. Slater, commercial director of A.E.C., Ltd., have been appointed as directors of the company. Mr. I. Donaldson will continue as secretary. Mr. John Thornycroft has resigned as chairman of Thornycroft (Australia) Pty., Ltd., and Mr. Roger Thornycroft has resigned as a director of Thornycroft South Africa (Pty.), Ltd. Mr. J. D. Slater will be appointed a director of both companies.

Contracts

DAVY AND UNITED ENGINEERING COMPANY, Ltd., a member of the Davy-Ashmore Group, has received an order from Shelton Iron and Steel, Ltd., for the design, supply and installation of oxygen-blown Kaldo Furnace plant at its Etruria Works, Stoke-on-Trent. The contract is valued at approximately £1,000,000. Davy-United will also be responsible for the overall engineering of the whole of this project, which will comprise the first complete steel melting shop in the United Kingdom to use only Kaldo furnaces. These furnaces will have a capacity of 55 tons of liquid steel at each charge.

THE DEMOLITION and CONSTRUCTION COMPANY, Ltd., a member of the Cementation Group, has been awarded a contract valued at £198,000 for building work for the B.P. Refinery at Llandarcy. The contract involves alterations to offices and ancillary buildings, and construction of a gatehouse and new mess room. Work on the project is expected to start in April, and it is scheduled for completion within twenty-one months. Architects for the project, which is being carried out on behalf of B.P. Refinery (Llandarcy), Ltd., are Messrs. J. M. Wilson, H.C. Mason and Partners.

HOLLOWAY BROTHERS (LONDON), Ltd., has been awarded a contract valued at a little under £90,000 for pile casting and driving at Tilbury Generating Station for the Central Electricity Generating Board. This is for the Tilbury " B " extension to this power station on the North Bank of the Thames at Gravesend Reach, the first stage of which was completed in 1955. Holloways constructed the main foundations and turbo-blocks for the earlier stage. Work on this contract has already started and will take seven months to complete. Consulting Engineers are Sir Alexander Gibb & Partners.

Miscellanea

ENGINEERING PLASTICS.—In the last paragraph of the article " Engineering Plastics " on page 425 *ante* it was implied that the cementable film of low-friction fluoro-carbon material was based upon polytetrafluoroethylene, " Teflon " TFE. In fact, it is basically fluorinated ethylene propylene, " Teflon " FEP. Not only can the new film be cemented with many standard adhesives, but it allows printing on the surface of high-temperature hose.

Award

MR. CHRISTOPHER S. COCKERELL, inventor of the " Hovercraft," has been awarded the " Viva " Shield for 1960 by the Worshipful Company of Carmen. The award is made annually for the most outstanding transport improvement.

CONTINENTAL AFFAIRS

by Our Continental Editor

Warm Air Tent for Building Construction

IN Heiligenhafen, East Holstein, a small town on the Baltic, a full-scale experiment is in progress regarding the possibilities of all-weather construction of buildings under cover of a closed nylon tent blown by warmed air.

The work is being carried out by the Federal and Land housing authorities in co-operation with the firm Fried. Krupp, Essen, maker of the tent and its ancillary equipment. This is believed to be the first occasion that a terraced block with twelve to eighteen flats is being built under such complete cover.

Fig. 1—Manufacture of large balloon tent inside a similar air-blown tent. The canvas is rubberised, with a window section coated with transparent plastic

Our first illustration shows the tent being manufactured inside a similar but smaller tent. The latter, seen in Fig. 2, is 24m long, 12·8m broad and 6·4m high and covers a floor area of 300 square metres. Made from a viscose-nylon material, the canvas weighs 450 kg and when packed occupies a volume of 1·6 cubic metres.

Six workmen are able to erect the building in four hours. It is supported by an internal air pressure of 15mm to 20mm H_2O generated and maintained by a radial blower of 24 cubic metres per minute which is driven either by a mains-operated electric motor or an internal combustion engine.

The bottom edge, which is weighted, forms an air-tight joint with the ground by means of a peripheral water cushion, and adapts itself to irregular contours. Additionally, the tent is secured by pegs. Wind tunnel tests have proved it to be stable in winds of hurricane force. Communication with the interior is by way of an airlock incorporating two double airtight doors. The pressure difference is so small that it not noticed when entering or leaving. Ventilators at the top allow vitiated air to be blown off.

The canvas is normally coated with synthetic rubber and is non-flammable. It is, however, possible to cover part of it with transparent plastic and in this way windows can be formed.

The tent at Heiligenhafen is of the same design but is 60in long, 25m wide, and 14m high. It requires 24,000 cubic metres of air per hour, of which 8000 cubic metres are needed for supporting it and the rest for air changes and losses. Two blower units supply the air, while a third is kept in reserve. The airlock is sufficiently big for lorries to pass through. No tent poles, frames or any other support structures are used.

The canvas consists of three parts, the cylindrical centre and the two spherical end sections, which are connected in an airtight manner by double lap joints. The joints are held together by stirrups on one piece threaded through holes in the mating piece and laced with nylon rope. Subdivision of the canvas is necessary in order to facilitate removal without damage when the building underneath has been completed.

Fig. 2—Exterior view of tent. The supporting pressure difference of 15mm H_2O cannot be felt. Access is by means of a single airlock formed by double doors. Air is supplied by a radial blower and can be heated if necessary

High-Frequency Welding Transformer

A portable welding transformer of 4·5kVA for an input of 250V, 200 c/s has been put on the market by Robert Bosch G.m.b.H., for use in conjunction with suitable high-frequency generators and rotary frequency converters with ratings of at least 5kVA. Regulation of the welding current is done on the primary side by magnetic coupling, by means of a switch which covers the range 50A to 130A in seven steps and also has an "off" position.

The transformer weighs only 25 kg and measures 345mm by 235mm by 385mm. It is therefore particularly suitable for erection work on sites, but has many other applications in repair jobs as well as series production. The maker states that because of its high frequency of 200 c/s the arc can be struck far more easily than with current of 50 c/s and shows characteristics very close to those of a d.c. arc. Stability is said to be remarkable, due to a tendency to increase its diameter without splutter. This gives the cathode spot and therefore the pool of metal a higher temperature. This is stated to be particularly noticeable with electrodes of small diameter. The welding of thin sheet materials is greatly simplified. Nearly all kinds of commercially available electrodes of 1·25mm to 3·25mm diameter can be used including electrodes for the welding of grey iron castings.

Portable welding transformer of 4·5kVA rated capacity at 200 c/s. The input voltage is 250V; the welding current can be controlled in seven steps over the range 50A to 130A

Daimler-Benz Museum

The opening on February 25 of the new Daimler-Benz works museum in Stuttgart-Untertürkheim marks the seventy-fifth anniversary of the motor-car invented by Karl Benz in 1886. Besides pictorial material illustrating the rise of the two firms which amalgamated in 1926 to form the Daimler-Benz A.G., the musum has 120 full-size exhibits of cars and engines, including many early designs, either as originals or replicas. Since its opening in provisional premises in 1951, the exhibition, now permanently housed on three storeys totalling 3520 square metres, has attracted over 500,000 visitors, including a high proportion of foreigners.

CONTINENTAL AFFAIRS *(continued)*

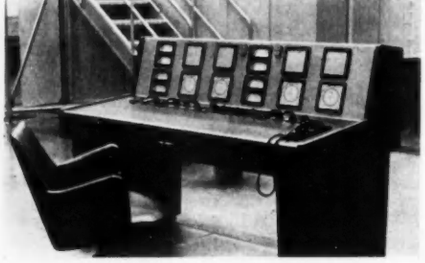
Nuclear research station at Gross-Welzheim (Lower Franconia)

German Nuclear Research Centre

AT the end of last year the buildings of the AEG nuclear research centre at Gross-Welzheim (Lower Franconia) were completed (Fig. 1). The essential part of the centre is a research reactor which first became critical on January 27. It is a design similar to the " Argonaut " reactor developed by Argonne National Laboratory, but by contrast it has no fixed tank for the moderator water. The water is contained in the same canisters in which are mounted the fuel elements. This, it is stated, gives the reactor an outstanding degree of flexibility.

The reactor is to be applied to the study of thermodynamic and hydraulic phenomena, and to problems of neutron physics arising in the design of nuclear power stations. Since the instrumentation is similar to that of a large reactor, the installation can also be used for the training of personnel for nuclear power plants. In addition, it is intended to use it for trials of newly-developed instruments for reactor measurements.

As fuel, U238 is used with a 20 per cent enrichment with U235. The channels for charging with fuel elements are arranged in two concentric octagons. Depending on the experimental conditions, either the outer or the inner ring is charged with elements. As principal moderator, demineralised light water is used, while graphite serves as reflector and auxiliary moderator. The graphite is made up of blocks which are cut in such shape that no jointing material is required. Shutting-down and controlling is done with sixteen cadmium sheets which are rivetted to aluminium sheets. These plates are actuated in pairs by eight drive mechanisms. In operation,



Control desk of testing reactor

the aluminium plates are held in place with the help of electromagnets, so that they can be let drop at any time for rapidly shutting down the reactor. Several channels equipped with geiger counters and ionisation chambers serve for measuring the neutron flux, and for maintaining the safety of operation.

For surveying the level of radioactivity in the building, several gamma counters are mounted in different parts of the reactor hall in conjunction with ionisation chambers. A central instrument cabinet houses the amplifiers and limit units as well as the recorders and interlock relays. The reactor is operated from a central control desk (Fig. 2).

The reactor building is a windowless reinforced concrete structure measuring 19m by 12m and 7m high. Doors are fitted with rubber seals. All liquid waste is collected in tanks and checked for radioactivity before it is allowed to enter the drains. Fresh air enters the ceiling air ducts of the reactor hall through a filter, while vitiated air is exhausted through floor channels. The surveillance instruments continuously check radioactivity in the air. If this exceeds a certain preset value, the quick-release flaps of the air ducts are automatically closed.

Portuguese National Civil Engineering Laboratory

The National Civil Engineering Laboratory, Lisbon, is well known for advanced research on dams, in particular by means of model tests. A recently published report* deals with rupture tests of models of arch dams which, it is stated, provide a means of judging the safety of dam structures in a way other than through the determination of elastic stress. Analysis of the various conditions that can produce rupture indicates that the most probable causes are weakness of the concrete or of the foundation rocks. This means that the models must be loaded with the hydrostatic pressure and the dead weight, which should increase in the same proportion until failure occurs. The safety factor of the dam (defined as the ratio between the actual compressive strength of the concrete, and the hypothetical strength for which rupture occurs under normal loads) can be determined from the model tests. Another very important factor, it has been found, can also be determined from these tests. This is the " factor of adaptation," defined as the ratio between the maximum stress in the structure that occurs under the maximum design loads, and the compressive stress of the material at which the dam would rupture. The report considers the conditions of similarity which have to be fulfilled, and the definitions of the properties of the materials of the prototypes and of the models. Weight and hydrostatic forces are simulated by systems of inclined jacks. First test results indicate in arch dams the existence of very high safety factors (over 10) and also important factors of adaptation.

A method for studying the transport of sand by the sea by means of sand labelled with radioactive silver (Ag 110), has been improved by the laboratory.†

Another report‡ refers to the results of field tests carried out in alluvial soils down to a depth of 45m and to corresponding laboratory tests. The authors particularly stress the correlation found between the shear strength, as measured by vane tests, and as measured by direct shear tests in the laboratory under the assumption—justified by geological evidence—that the consolidation of the different layers has attained its ultimate value. Data obtained from standard penetration tests, on the other hand, were found to be invalid for this type of soil.

Critical appraisals of completed buildings, including analysis and discussion of the solution adopted, seem a promising means to elucidate building construction problems.§ Such an analysis is presented concerning a dwelling block recently completed in Lisbon. Different aspects of the design, which are discussed in turn, include the general layout, circulation and entrances, services, sound and heat insulation, finishes, and the structural system adopted.

How problems of structural design may be approached from the angle of operational research is pointed out in a paper by J. Ferry Borges.|| As an example, the author describes the determination by linear programming of the best route for a road crossing a valley.

Sixth International Galvanising Conference

Arrangements are announced for the Sixth International Galvanising Conference to be held at Interlaken from June 4 to 9, 1961.

Twenty-three papers will be presented, and technical sessions will be held on bath heating, the metallurgical aspects of the process, welding, and after-treatments for galvanised steel. In addition there will be a session on works practice and informal discussions on management problems, as well as special meetings on sheet, strip, and wire galvanising.

Works visits to jobbing plants in Switzerland and to strip, wire and tube galvanising plants in Italy are being arranged, and there will be an exhibition of equipment and materials used in galvanising and of applications for galvanised steel.

Copies of the Preliminary Notice, which contains a registration form, may be requested from the Zinc Development Association, 34, Berkeley Square, London, W.1. Those wishing to attend should write without delay, in order to ensure hotel accommodation.

Light Metal Conference

During the period June 20 to 24, 1961, the Fourth International Light Metal Conference is to be held at Leoben (Styria). The conference is being organised by the Montanistische Hochschule, Leoben, in co-operation with the Austrian light metal industry. The theme will be " Light Metals in Light Construction, in Architecture, and in Special Fields." The preliminary programme mentions some forty-five papers and lectures dealing with metallurgical, production, design, and economical aspects of light metals. Some of the lectures and subsequent discussions will be simultaneously translated into English, German, and French. Works units, and an exhibition of photographs, drawings, and models relating to the lectures, are also being arranged. Those interested are asked to write to the Secretariat, Fourth International Light Metal Conference, Montanistische Hochschule, Leoben/Stmk, Austria.

* Rocha, Manuel, and Serafim, J. Laginha, "O Problema da Segurança das Barragens-Abobada," Memória No. 142, Laboratório Nacional de Engenharia Civil, Lisboa. Price 12$50.

† " Observation des mouvements du sable sous l'eau au moyen de l'argent 110," by A. Gilbert, Mémoire No. 143 Price 45$.

‡ "Caracteristicas geotécnicas de aluviões determinadas 'in situ,' " by J. B. Folque and E. Dias, Memória No. 146. Price 20$.

§ " Apreciação critica de edficios o blocko das Aguas Livres," by Gomez, Ruy José. Memória No. 153.

|| " A investigaço operacional e o dimensionamento das estruturas," by J. Ferry Borges. Memória No. 147. Price 20$.

THE AMERICAN SCENE

By Our American Editor

Hydro-Electric Power Project with Pumped Storage at Niagara Falls

No. I

The Niagara Power Project of the State of New York was formally dedicated and commenced commercial power generation on February 10. When ultimately completed in 1963, the scheme will comprise twenty-five turbo-generators capable of producing a total of 2190MW, making it the largest hydro-electric power station in the western world. The principal features of the scheme are the Robert Moses Niagara power station, with thirteen 150MW generators, the Tuscarora storage reservoir of 60,000 acre-feet and power station, with twelve 20MW reversible pump turbines, an intake structure above the Niagara Falls, a 4000ft long canal connecting the two power stations, and miscellaneous canal and conduit structures.

THE Niagara Power Project was officially dedicated at Lewiston near Niagara Falls, New York, on February 10, when Governor Nelson A. Rockefeller threw a switch to send 150MW of power from the first of its generators into the local grid of the Niagara Mohawk Power Corporation. When all its twenty-five turbo-generators are in operation early in 1963, they will be capable of producing 2190MW, 216MW more than those at the Grand Coulee dam on the Columbia River in Washington and 310MW more than those at the St. Lawrence Power Project near Massena, New York, which is connected with the present scheme by a 300-mile transmission line.

The Niagara scheme involves an investment of 720 million dollars and was financed entirely by private capital without tax support or public credit. It is being constructed by the Power Authority of the State of New York, which is a public corporation, created by the State and mandated to develop the full power potential of the Niagara and St. Lawrence rivers for the benefit of the people and to preserve and enhance the scenic beauty of the Niagara Falls and river. The first power was produced only three years and eleven days after the U.S. Federal Power Commission issued a licence on January 30, 1958. Congress had resolved a prolonged controversy over the private *v.* public development of the Niagara River power potential in favour of New York State in a bill signed by President Eisenhower on August 21, 1957.

Overall Design

The principal features of the project are: (1) The Robert Moses Niagara Power Plant, situated on the Niagara escarpment about 5 miles below the Falls. (2) The Tuscarora pumping-generating station, a dual-purpose plant, situated about three-fourths of a mile east of the main power station. (3) Two intakes and intake gate structures about 2½ miles above the Falls. (4) Two parallel underground reinforced concrete conduits, each 4¼ miles long, 46ft wide and 66ft high, to carry water from the intakes to an open power canal near the Tuscarora reservoir power station. (5) The power canal, 4000ft long, 500ft wide and 110ft deep, which connects the two power stations. (6) The Tuscarora storage reservoir, which covers 1880 acres and holds 60,000 acre-feet or 20,000 million gallons of water. (7) A 300-mile tie-line linking the Niagara and St. Lawrence Power Projects. (8) A comprehensive programme for restoring, preserving and enhancing the scenic and recreational resources of the "Niagara Frontier."

The Niagara River is the boundary separating New York and Ontario between Lakes Erie and Ontario. Only 36 miles long, it drains four of the five Great Lakes, an area of almost 264,000 square miles, equal to about one-twelfth of the area of the continental United States. Its average annual flow is 203,000 cusecs and its maximum recorded flow is about twice the minimum. It is one of the world's most dependable sources of water power. This enormous flood of water plunging over a 160ft precipice has made Niagara Falls one of the world's most majestic scenic attractions. To protect this natural wonder, diversion for power production has been restricted, first by the Burton Act of 1906 and, since 1909, by treaties between Great Britain or Canada and the United States.

The Niagara Power Project is being built under the terms of the U.S.–Canadian treaty of 1950, which increased the amount of water available for power purposes while still ensuring an adequate flow to preserve the beauty of the Falls. The treaty provides that no less than 100,000 cusecs of water must flow over the Falls during daylight hours in the tourist season from April 1 to October 31. At other times the flow can be reduced to 50,000 cusecs. The water available for power generation is to be divided equally between the two countries.

Fig. 1—Early excavation work proceeding on a day-and-night basis, January, 1959

THE AMERICAN SCENE *(Continued)*

Fig. 2—Commencement of penstock and lower construction crane trestle erection, July, 1959

It is perhaps rather astonishing to engineers accustomed to the scale of British rivers to think in terms of 100,000 cusecs of "compensation water." The figures just given show that, on summer days, about half the total flow is used for power, and at other times about three-quarters. The resulting output of power is so vast that one might be tempted to inquire into how the figure for compensation water was fixed, and if it could have been reduced. The answer can be given quite specifically : the area is the greatest tourist centre for hundreds of miles around, and the number of visitors who come to see the Falls and the average amount which each one spends is accurately known. The total tourist income is then quite astronomical when compared with possible additional power revenues. So the natural grandeur of the Falls has a high value in dollars, and paradoxically for the hydro-electric engineer, it pays to waste rather than to utilise sufficient flow to maintain the spectacle, which at half-flow, but with "remedial works," is unimpaired and fills the visitor with awe. Turning now to that proportion of the Niagara which is harnessed to useful ends, and is prevented from dissipating its energies in a panache of spume and thunder, we find that the layout of the principal elements on both the Canadian and U.S. sides follows closely similar lines. Each country's works consist of an intake a mile or two upstream from the Falls with diversion tunnels leading to a main stage of power generation in the Niagara gorge, at power stations on opposite banks of the river about 5 miles down river from the Falls. This length of diversion gives a head of almost 300ft. In addition each scheme has a pumped storage reservoir served by a pumping-generating station situated at the end of the high-level section of the main diversion. The Canadian works were described in our issue of December 18, 1959.

The Niagara project was designed to make maximum use of the United States share of the water available. It was also designed to capture for power production all but a few feet of the hydraulic head in the 326ft difference in water levels between Lakes Erie and Ontario. At the Falls the Niagara River drops spectacularly through 160ft. It also drops some 50ft in the rapids above the Falls and about 115ft in the various rapids below the Falls.

History of Power Generation

Niagara River water has been used for power generation for slightly more than 200 years. Chabert Joncaire, Jr., a Frenchman, completed a saw-mill in 1757 on the banks of the river in what is now the City of Niagara Falls. This is the first recorded commercial use in that area of flowing or falling water as a natural source of power. This primitive mill was equipped with a water wheel, fed by a tiny loop canal, and, according to local historians, used a 6ft head to develop an estimated 6 h.p. of energy. Joncaire burned his saw-mill when he had to go to Fort Niagara during the French and Indian War and the remnants of his plant together with the island now known as Goat Island were taken over by an Englishman, John Stedman, whose goats gave the island its name. Stedman rebuilt the saw-mill and operated it until the region passed into the hands of the United States after the revolution. Augustus Porter, a surveyor, acquired the Stedman property and much additional acreage. He also rebuilt the saw-mill, only to have the English burn it in the war of 1812. Porter, stubborn and tenacious, reconstructed his mill and added other works, including clothing factories, a paper-mill, forge and carding and spinning machines. Porter died in 1849, his dream of building a large canal and developing water power on a large scale unfulfilled. His heirs sold his property to Caleb S. Woodhull and others in 1852. They formed the Niagara Falls Hydraulic Company, raised 500,000 dollars and proposed to build the canal envisaged by Porter to draw water from above the Falls to the high land below. This was "for the purpose of carrying on and conducting manufacturing, chemical and mechanical business at the Village of Niagara Falls by means of water-power drawn from the Niagara River immediately above the Falls." Woodhull and his partners ran out of money before the task was finished. The company was reorganised as the Niagara Falls Water Power Company in 1856. In 1857 the intake and river portions of the canal were finished. Limited use of the water began in 1858. Financial troubles pursued these persistent men. In 1860 Horace H. Day, one of the venturers, purchased the rights and reorganised the promotion as the Niagara Falls Canal Company. Excavation continued intermittently for many years, stopping for lack of funds, resuming when new capital was obtained. In 1875 the canal water was first used to power a flour mill on the high bank near the canal basin. Water taken from the canal through wooden flumes at a head of 25ft was carried to turbines at the bottom

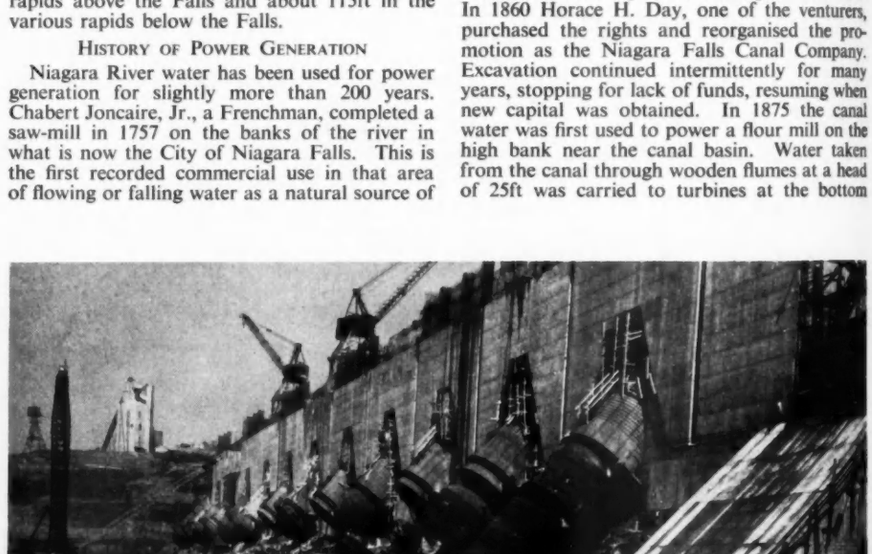


Fig. 3—Penstock erection in progress, with power and control tunnels in foreground completely enclosed, April, 1960

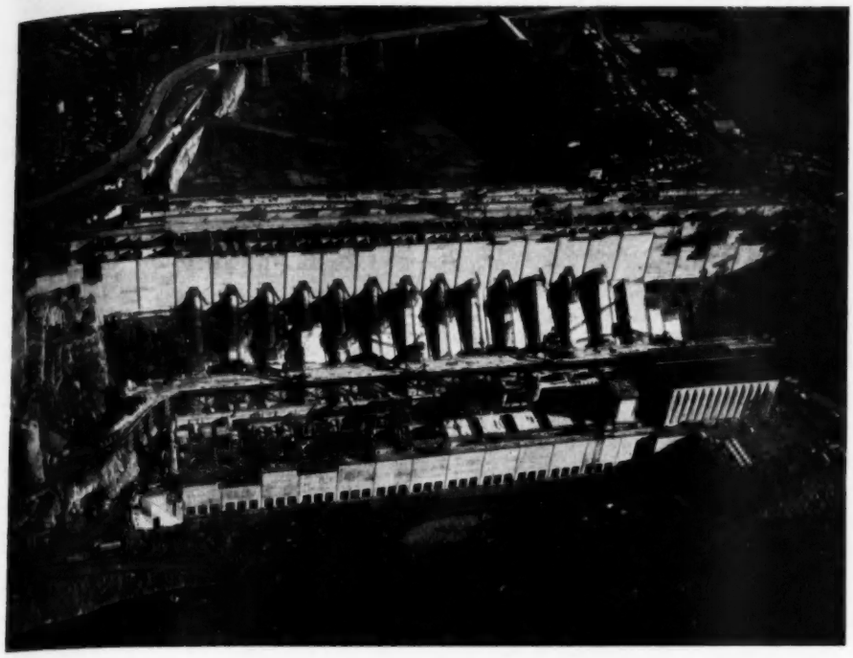


Fig. 4—Aerial view of the entire power station, 82 per cent completed, with Niagara River in foreground, November, 1960

of the shafts. In 1877 the ill-starred canal company collapsed for want of money and the Sheriff's gavel transferred the company on May 1, 1877, to a Buffalo leather manufacturer, Jacob Frederick Schoellkopf, for a bid of 71,000 dollars and a subsequent 5000 dollars additional to Horace Day.

Schoellkopf was the man who finally got Niagara water power into fairly large-scale use. The power capacity of the canal was estimated to be from 2746 h.p. at a 20ft head to 27,456 h.p. at a 200ft head. Schoellkopf formed the Niagara Falls Hydraulic Power and Manufacturing Company in 1878. In 1881 the horizons expanded as electricity was produced at Niagara for the first time. A hydro-electric generating station was built in Quigley's mill on the canal. Water wheels ran the machinery of the mill and an arc-light machine installed by a new Schoellkopf company, the Brush Electric Light and Power Company. On December 14, 1881, arc-lights illuminated some streets and shops as electricity came to stay in the " Niagara Frontier." Schoellkopf and his associates started construction of a hydro-electric plant in 1895. Called Power Station No. 2 , it contained fifteen turbines with a capacity of 34,000 h.p. These turbines were run by water dropping through penstocks and powered thirty-one generators. The Aluminum Company of America, then known as the Pittsburgh Reduction Company, purchased nearly half of this power.

Electricity was the romantic product of the period. Large-scale capital became engrossed in power and light, and in 1893 still another plant was started on Niagara's upper river. This would employ a deep tunnel and the generation of power in a central plant if the transmission problem could be solved. The a.c. motor devised by Nikola Tesla was adopted and by April, 1895, the first hydro-electric unit in the Niagara Falls Power Company's Power House No. 1 was tested successfully. In August, first power was delivered to the Pittsburgh Reduction Company and on November 16, 1896, electricity produced at Niagara Falls turned a motor and lit lamps in Buffalo. The power company expanded, and by 1904 the turbines of twin structures, now the Edward Dean Adams station, were developing 105,000 h.p., turning generators capable of producing 80MW of hydro-electric power. The company later built the Rankine station on the Canadian side, with a rating of 95MW. Both plants were interconnected, the city's population expanded and many of America's great industries using cheap power had their inception on the " Frontier."

Schoellkopf had been busy, too. In 1903 his company started building the power plant bearing his name. It finally attained a capacity of 334,800kW. However, before the Schoellkopf plant had been expanded to its peak capacity, his company merged with the Niagara Falls Power Company under that name. Later these hydro-electric plants merged again and their operations became part of the Niagara Mohawk Power Corporation. The scramble to harness the waters of the Niagara and to establish industry along the " Niagara Frontier " resulted in a complete di regard of the natural beauty of the river and its serpentine and scenic path through the gorge to Lake Ontario. Industrial plants were erected on its banks, heavy smoke often obscured the view of the river and the thousands of tourists who made the pilgrimage to the Falls were compelled to travel a chemical-scented route to one of the natural wonders of the world. The Canadians on their side of the river had " enhanced and preserved " their natural water front along the river with parks, parkways, gardens and recreation facilities. The Americans profaned their waterside landscape with unrelieved ugly smoke-spewing structures and a constant flow of industrial refuse into the waters of the river. Only the action of the New York State Government in acquiring land at Prospect Point and other areas immediately adjacent to the Falls in 1885 preserved some of the aesthetics of nature.

In 1954 the New York State Power Authority was reorganised, and work on the St. Lawrence Power Project finally got under way, as a joint project shared with the Hydro-Electric Power Commission of Ontario. First power was generated in July, 1958, two years ahead of the original schedule. On the Niagara, Canada had moved swiftly after the ratification of the 1950 Treaty to develop its share of the river, but on the American side it required the collapse of the Schoellkopf plant in 1956 and a power shortage before Congress decided that New York State, not five private utilities, should be entrusted with preserving and enhancing the beauty of the Niagara River, Falls and Gorge and developing the power potential consistent with genuine conservation.

Congress finally cleared the way for the Niagara Power Project in a bill signed by President Eisenhower on August 21, 1957. Five

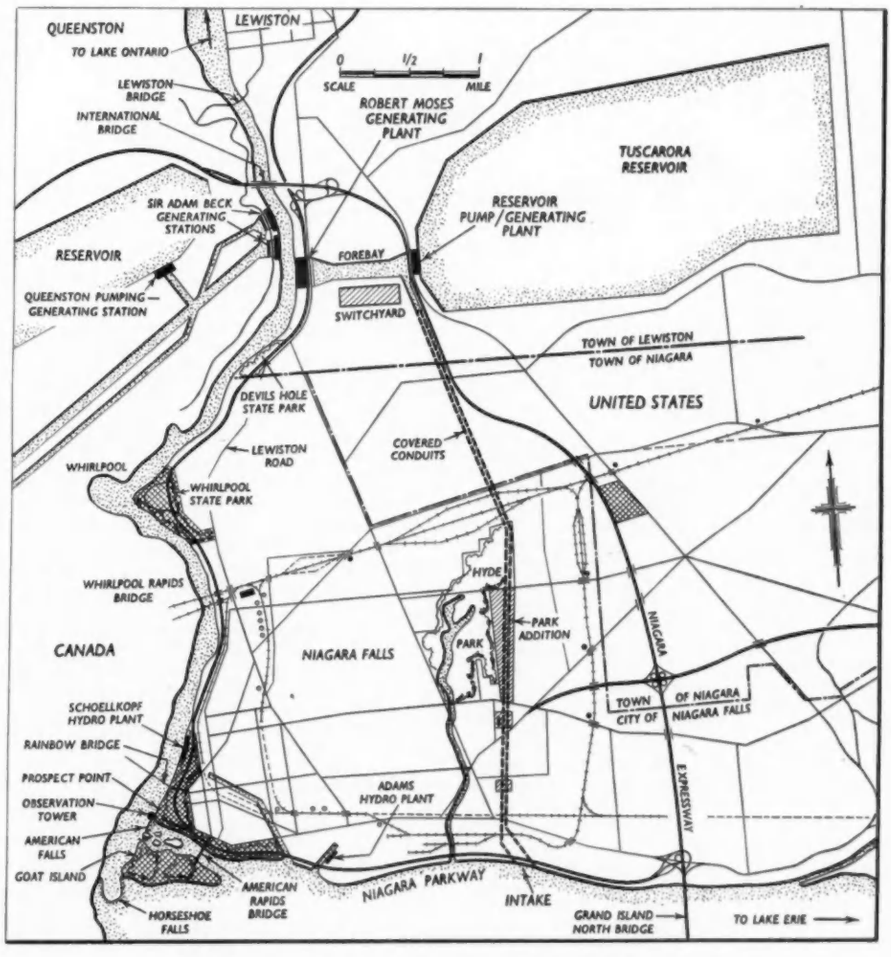


Fig. 5—Map of the Niagara power project and related improvements

THE AMERICAN SCENE *(Continued)*

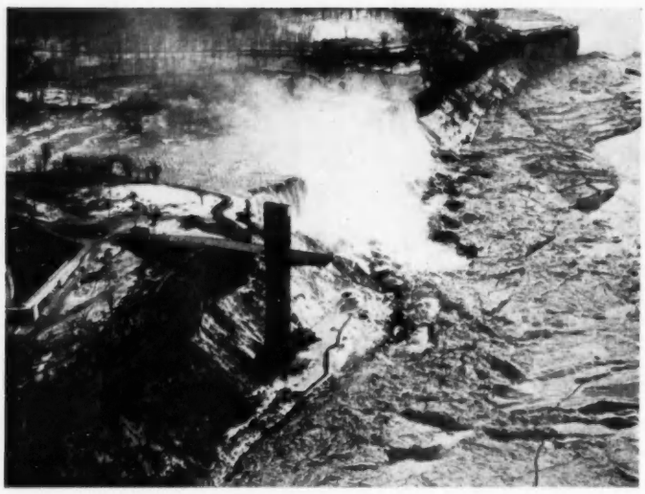


Fig. 6—Aerial view of the American Falls during the recent severe cold, with the Prospect Point Observation Tower for tourists completed

months later, on January 30, 1958, after further skirmishes in Washington, the Federal Power Commission gave the Power Authority a workable licence. The Authority was ready. Within four days a large construction contract was awarded and many others followed in rapid succession. The Federal Power Commission licence runs until the year 2007, and the power contracts are generally for twenty-five years. There are those who complain that full benefits may not be realised for four or five years because of a temporary oversupply of power. Experience has shown that power will not long remain in oversupply. Industry will gravitate to any area where low-cost power is available. The high-tension transmission tie line between the Niagara and St. Lawrence plants will enable the more efficient use of both, increase the amount of firm power and contribute to its economic distribution throughout the marketing area.

(To be continued)

Prospects of Gas Centrifuge Technology

AFTER a careful study of the gas centrifuge process, the U.S. Atomic Energy Commission has come to the conclusion that the practical use of this method by any nation for producing weapons material is several years away. The Commission does not minimise the potential importance of this process, however. Although the gas centrifuge does not pose an immediate prospect for the production of weapons material, there is no doubt that it will introduce an additional complicating factor in the problems of nuclear arms among nations and the American quest for controlled disarmament. If successfully developed, a production plant using the gas centrifuge method could be simply housed. Its power requirements would be relatively small, and there would be no effects of the operation which would easily disclose the plant. Therefore, a clandestine plant would not be as easy to detect as a gaseous diffusion plant.

The theory of the gas centrifuge process is to pass uranium in gaseous form (uranium hexafluoride) through a centrifuge which spins at very high speeds. There is a slight difference in the weight of the uranium-238 and uranium-235 isotopes. Consequently, it is theoretically possible to separate these isotopes just as one can separate cream from milk by centrifugation. Only the uranium-235 part of natural uranium (U-238) is fissionable and can be used for weapons purposes. Uranium-235 constitutes only 0·7 per cent of natural uranium. The other 99·3 per cent of uranium-238 is of no use for weapons ; therefore, separation is necessary.

Two potential advantages of the gas centrifuge method, as compared with the gaseous diffusion process now used in the United States for uranium isotope separation, are the reduced demand for electric power and the need for fewer units in series to produce the desired enrichment of uranium-235. Furthermore, it appears to be particularly well suited for low-capacity installations. The centrifuge process has the interesting theoretical property that the separative work performed varies with the fourth power of the speed, all other factors being equal. This means that doubling the speed would, in theory, increase the separative work performed by the unit by a factor of sixteen. With this potential, as progress is made in materials of construction and equipment design, enthusiasm rises for the application of this process to the separation of uranium isotopes. In at least one respect this is a desirable situation since promising processes should be developed for uranium-235 separation as a step toward possible improvement in the economics of nuclear power.

A review by the U.S. Atomic Energy Commission of available information on the gas centrifuge machines indicates that these machines cannot now be used in a production plant without further development work. So far, centrifuge units have been operated only as single laboratory models for isotope separation. These machines are complex and expensive. Even after substantial improvements have been made, thousands of gas centrifuges probably would be required to produce enough enriched uranium for one crude weapon per year. Including auxiliaries, a plant of this type might cost several thousand dollars per centrifuge.

The general areas in which problems still must be solved before a satisfactory process is possible with the current centrifuges include : (1) The reliability of the present experimental machines for continuous, long-term service with uranium hexa-fluoride must be established. (2) A model of the machine satisfactory for mass production of identical units must be developed. (3) A method must be developed to provide for the introduction and removal of gas when the machines are grouped as would be necessary in a production plant. (4) The auxiliary processes, services and instrumentation necessary for plant operations have to be determined. None of these problems is simple to solve, and excellent technical and industrial talent are required.

The United States has followed development of this process for some time. The gas centrifuge was one of the methods investigated during World War II. Development work on the centrifuge method had not progressed as far as other methods when it became necessary to select the processes to be used in production plants. The United States temporarily discontinued work on the centrifuge and went ahead with gaseous diffusion, thermal diffusion and the electromagnetic methods for the production of uranium-235. Although the United States ultimately continued to employ the gaseous diffusion method as the most economical process available, the Commission has not lost sight of the gas centrifuge. The A.E.C. resumed research on the centrifuge method in 1953 and expanded this work gradually as the technology advanced. Most of the Commission's research work has been carried out at the University of Virginia.

As the technology advances, it will be possible to make more realistic appraisals of the economic attractiveness of this method for the separation of uranium-235. The Commission has recently increased the United States effort on the centrifuge programme. It is now expected that the total effort will be at a level of 2,000,000 to 3,000,000 dollars per year. Because of its potential significance to the production of weapons, however, the programme is classified.

Projections of possible gains in the gas centrifuge process indicate the possibility that the process may become economically attractive in the future. However, this would require very substantial further advances in the technology. Since there has been considerable commercial interest expressed in possible industrial application of the gas centrifuge process to the development of economic nuclear power, the Commision has approved a programme under which private industry in the United States will be permitted to work on the centrifuge process with private funds, under appropriate conditions and security.

Scientists in West Germany and the Netherlands also have worked to develop the potential of the gas centrifuge process for its interesting scientific and commercial possibilities, particularly in the production of low-enriched uranium for civilian research and power reactors. In July, 1960, representatives of the U.S. Department of State and of the U.S. Atomic Energy Commission discussed centrifuge technology with the West German and Netherlands Governments and the United States asked that Germany and the Netherlands give consideration to the control of gas centrifuge technology. These two countries shared the concern of the United States over the possible application of the centrifuge process for weapons production.

The West German Government recently announced that it had taken steps to control the dissemination of information on the gas centrifuge process. The United States understands that the Netherlands Government is actively studying the question of applying controls to its work. The United States also discussed the gas centrifuge question with the United Kingdom where classification criteria are similar to those of the United States on the gas centrifuge process.

The United States has supported broad international safeguards to ensure that plutonium, as well as any other nuclear material used or produced in peaceful work, are not diverted to weapons uses. The General Conference of the International Atomic Energy Agency, which met in Vienna in September, endorsed proposed safeguards to apply to reactors and special nuclear materials that will be subjected to I.A.E.A. controls. The principle of these safeguards can be extended to apply to the gas centrifuge.

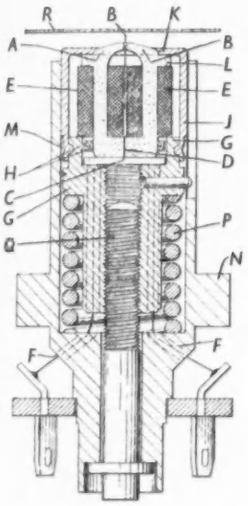
BRITISH PATENT SPECIFICATIONS

The dates printed are those of application and publication on completion. Copies of specifications may be obtained at the Patent Office Sales Branch, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each

ELECTRONICS

861,551. December 12, 1958.—MAGNETIC HEAD, Standard Telephones and Cables, Ltd., Connaught House, 63, Aldwych, London, W.C.2.

The present invention is based on the problem of creating, particularly for magnetic drum-type storage devices, a magnetic head which is suitable for mass production, and is particularly for use in magnetic drum storage devices. An embodiment of the invention is shown in the accompanying drawing. The head consists of two symmetrical stacks of sheets *A* with a recording gap defined by the silver foil *B*, and with a further air-gap *C* formed by the surfaces *D* which are surface-ground and butt-joined. The two stacks of sheets carry the windings *E*, of which the leads are passed through holes *F* in the head-support *G*. The two stacks of sheets, representing the two parts of the magnetic core, are held together by rings *H*. When the core is assembled the two halves



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of the core are arranged against each other, the spacing foil being inserted in the recording gap, and the rings with their bores forming a tight fit are slipped over the lower ends of the two halves of the core, so that at first the parts *A*, *B*, *E* and *H* form a continuous whole. The magnetic core, held together by the tight-fitting rings, is now loosely inserted from above into the holding device *G* for the magnetic head and the adapter sleeve *J* is slipped over the core. This sleeve is provided with a slot and, in turn, at the points *K* presses the magnetic core at its upper end into a further tight fit. This adapter sleeve rests on the extensions of the sheet stacks. After it is slipped on, the adapter sleeve is firmly connected with the holding device for the magnetic head by the indented ring at *M*. As will be further seen from the drawing, the magnetic head is guided in a casing *N* in telescopic fashion and can be displaced in opposition to the force of a spring *P* by a fine-thread screw *Q* towards the recording medium *R*.—*February* 22, 1961.

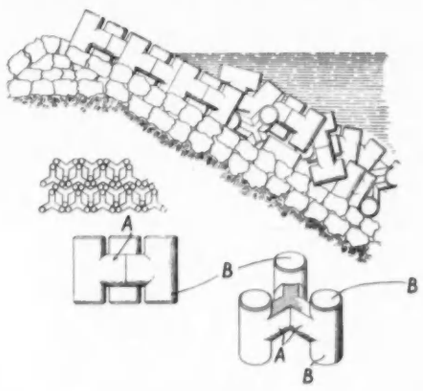
861,727. August 26, 1958.—SEQUENTIAL SWITCHING APPARATUS, Microcell, Ltd., 9, Kingsway, London, W.C.1. (*Inventor : John Louis Carroll.*)

This invention relates to apparatus for switching a number of circuits in sequence and utilises a sloping waveform signal generator, the output of which is applied to the bases of a series of transistors so that each becomes conductive in succession. There is a current-operated switching means in the emitter-collector circuit of each transistor, which is arranged to interrupt that circuit as each transistor passes current, thus cutting off that transistor. Thus each transistor will become conductive and then cut off a short time later, the various transistors becoming conductive in sequence. The current-operated switching means might comprise the operating coil of a relay, connected in the collector circuit of the associated transistor. The relay would have to be a latching relay or have a self-holding circuit so that the emitter circuit continued to remain interrupted by the relay contacts. If such a relay is used, contacts on the relay can be used to operate further circuits as required. If it is merely required to pass short duration currents through a number of circuits in succession, instead of employing relays, fuses may be arranged in the emitter circuits of the various transistors. With this latter arrangement, as each transistor becomes conductive its fuse would pass current and then blow to interrupt the emitter circuit.—*February* 22, 1961.

CONSTRUCTIONAL ENGINEERING

861,626. October 13, 1959.—COMPONENT FOR BREAKWATER, Tribars, Incorporated, 863, Halekauwila Street, Honolulu, Hawaii, United States of America.

This invention relates to the construction of components for integration into stable breakwater structures. The drawings show what is referred to as a "tribar." The tribar has a central spider with three evenly spaced legs *A*, attached to the end of



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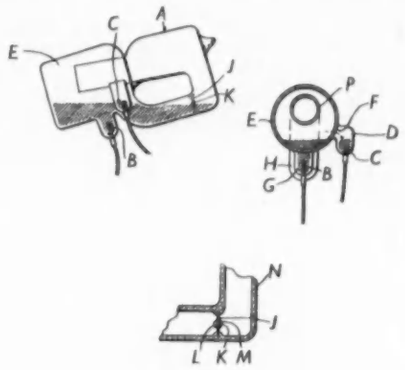
each of which is a crossbar *B*. The tribar is preferably fabricated of concrete, cast as a single unit, but could be fabricated of any other material having suitable properties of hardness and strength, and a high specific gravity. The upper drawing shows a rubble-mound breakwater constructed of tribars. A prepared rock base has a single layer of tribars arranged in a more or less uniform pattern above and extending slightly below the water line. A randomly placed compound layer of tribars is placed below the water line where obscured visibility prevents setting of the components in a uniform pattern. It will be noted that no plane surfaces of any consequence exist on the tribar. By positioning the crossbars at right angles to the spider legs, and having blunt ends on the crossbars, no wedges are formed which would tend to work their way under and dislodge adjacent components of the breakwater. The crossbars are sufficiently short and stubby and the overall component is sufficiently compact so that no legs are apt to act as levers to displace adjacent components.—*February* 22, 1961.

ELECTRICAL ENGINEERING

861,653. May 7, 1958.—ELECTRIC CONDUCTING LIQUID SWITCHES, Engel and Gibbs, Ltd., Warwick Road, Boreham Wood, Elstree, Hertfordshire. (*Inventor : Ernest Emil Otto Engel.*)

This invention relates in particular to so-called "mercury" control switches with provision for delayed make and break. One embodiment is shown in the upper drawing of a delay break switch in its inoperative position. The preferred form of switch comprises a glass envelope *A* having a varying cross section and provided with a pair of electrodes *B* and *C* which project into the envelope. The envelope is evacuated or otherwise filled with an inert gas and a predetermined quantity of mercury or other electrical conductive fluid is introduced into it. Referring now to the second drawing it will be seen that the electrode *C* is sealed into a bulb-like extension *D* which projects from one side of the main section or compartment *E* of the envelope and communicates therewith through an aperture *F* in the envelope. The electrode *B* is located in an extension *G* of the compartment and it will be appreciated that during operation both extensions will retain a certain quantity of mercury so that the electrodes act as mercury contacts with the main mass of mercury during its movement in the envelope. A tube *H* is provided to permit the escape of mercury from the compartment *E* of the switch. In this tube there is positioned a restriction in the form of a thin disc *J* in which is formed a small accurately calibrated hole *K* (see third drawing) to control the rate at which the mercury leaves the compartment *E* of the switch. The size of the hole determines the length of time during which the circuit between the electrodes *A* and *B* remains made. The circuit between the two electrodes remains closed until the level of the mercury falls below the edge of the aperture *F* to the bulb *D*. The disc *J* is



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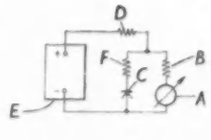
formed of a metal unaffected by contact with mercury such as platinum. The hole *K* is accurately calibrated during manufacture of the disc to give any required delay in the operation of the switch. During the manufacture of the disc, a globule of mercury is inserted into the hole, filling the hole and protruding therefrom on either side of the disc as shown at *L* and *M*. This causes the disc to be permanently wetted and ensures that no priming is necessary to start the operation of the delay device. A second section or compartment *N* is provided in the switch and acts as an air by-pass for the disc to ensure the smooth flow of mercury. It is formed with an extension *P* extending into the compartment *E* of the switch to prevent mercury from flowing down the air passage. —*February* 22, 1961.

INSTRUMENTATION

861,582. June 14, 1957.—COMPRESSED SCALE MEASURING INSTRUMENT CIRCUITS, Sangamo Weston, Ltd., Great Cambridge Road, Enfield, Middlesex.

This invention relates to a compressed scale measuring instrument circuit in which one end of an instrument scale may be greatly compressed relative to the other end. The drawing shows a schematic circuit diagram of a compressed scale instrument network connected to an electrical meter whereby the upper portion of the meter scale may be compressed in accordance with the invention The meter *A* may be an ordinary d.c. instrument having a substantially linear response to an applied voltage. Resistor *B* makes the meter suitable for voltage measurements. Diode *C* is of the type which exhibits a Zener voltage characteristic when subjected to a reverse-potential. The diode has a high inverse voltage characteristic up to the Zener voltage, but above the Zener voltage the impedance is small and substantially constant. The series-shunt network con-



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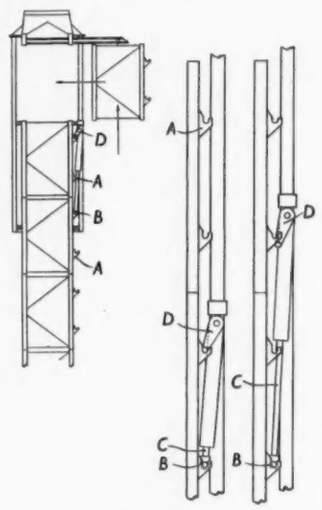
sisting of the meter *A*, two resistors *F*, *B* and diode *C* is connected in series with a resistor *D* and the entire network is connected to a source of d.c. voltage *E* to be measured. The polarity of the d.c. voltage source is such that the diode is connected in a reverse-potential

manner in the circuit so that there is no conduction through the diode for low values of d.c. voltage. When a sufficiently high reverse-potential is applied to the diode, the diode breaks down and conducts in the reverse direction. This breakdown, or Zener voltage for such a diode may be approximately 5V. The net effect, therefore, is that the diode and its series resistor *F* act as a shunt to the meter and series resistor *B* only when the voltage across the diode becomes equal to the Zener voltage of the diode. Until the Zener voltage is reached, the diode presents, in effect, an open circuit and the entire current flows through the meter in series with the resistors *B* and *D*. As soon as the voltage across the diode reaches the Zener voltage, the diode breaks down and acts as a low resistance circuit component. A shunt path for a part of the current is thereby provided around the meter and series resistor *B*. A much larger increment of voltage is now required to produce the same degree of deflection of the instrument as compared to the voltage increment necessary before the diode breakdown.—*February* 22, 1961.

CRANES

861,733. July 10, 1959.—Tower Cranes, Etablissements F. Potain et Cie, La Clayette (Saone and Loire, France).

An object of the present invention is to provide means for raising a portion or the whole of the tower of a crane. The tower of the crane comprises a main portion of successive square or rectangular elements. Each element carries a number of blocks *A* with an upwardly opening notch. These notches co-operate with a transverse finger *B* at the lower end of the piston-rod *C* of a hydraulic ram hinged to the jib head. A latch *D* is also pivoted on the head, this



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latch having a finger to engage the notches of the successive blocks. When the jib-head has to be moved vertically, the hydraulic ram is contracted and its finger is engaged into the notch of another block *A*. The ram is then expanded and the head is raised, the stroke of the ram being greater than the vertical distance between two successive blocks, the latch *D* rises above the next block with respect to the one in which it was engaged. The ram is then progressively contracted and the finger of the latch is engaged into the notch of the next block. When the jib head is to be lowered, the operation is reversed. —*February* 22, 1961.

RAILWAYS

861,234. June 4, 1958.—Apparatus for Adjusting the Level of Railway Rail Tracks, Nordberg Manufacturing Company, 3073, South Chase Avenue, Milwaukee 7, Wisconsin, United States of America.

According to the invention, apparatus for adjusting the level of railway rail tracks comprises spaced front and rear carriages mounted on wheels so that they can travel as a unit along the track. Track level adjusting equipment positioned between the carriages are provided with means for establishing two or more reference lines between the carriages. The track level adjusting means have indicating mechanism adapted to indicate the position of each rail relatively to one of the reference lines independently of the other rail. An example of apparatus in accordance with the invention is shown in the drawings.—*February* 15, 1961.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Mon., March 27.—North West London Branch : Compass Hotel, Watford, " Earthing and Earth Leakage Protection of Electrical Installations," J. A. Robbins, 7.45 p.m.

Thurs., March 30.—South London Branch : Greyhound Hotel, High Street, Croydon, Surrey, " Electricity in the Food Supply Industry," C. R. Ayling, 8 p.m.

BRITISH INSTITUTE OF RADIO ENGINEERS

Mon., March 27.—Medical Electronics Group : Post Graduate Medical School, University of London, Hammersmith, W.12, Symposium on " Electronic Instrumentation for Cardiac Surgery," 2.30 p.m.

Wed., March 29.—London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, Symposium on " Electronic Instrumentation for Nuclear Power Stations," 3 p.m.

CEMENT AND CONCRETE ASSOCIATION

Tues., March 28.—Museum Room, Technical College, Sunderland, " Prestressed Concrete," H. Kaylor, 7.15 p.m.

COMBUSTION ENGINEERING ASSOCIATION

Tues., March 28.—North Western Region : Bull and Royal Hotel, Fishergate, Preston, " Industry and the Clean Air Act," J. S. G. Burnett, 7.15 p.m.

Wed., March 29.—Criterion Restaurant, Piccadilly Circus, London, S.W.1, " Modern Developments in Water Tube Boiler Design," Heinrich Vorkauf, 2.15 p.m.

ENGINEERS' GUILD

Tues., March 28.—Essex Branch : Middleton Hotel, 119, High Street, Southend, Branch meeting, 7.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., March 27.—Birmingham Centre : Regent House, St. Phillip's Place, Colmore Row, Birmingham, " Hospital and Operating Theatre Lighting," S. Hubbold, 6 p.m. ★ Leicester Centre : Demonstration Theatre, East Midlands Electricity Board, Charles Street, Leicester, " An Electrical Engineer in Local Government Service," D. L. Richards and A. E. Griffiths, 6.15 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., March 27.—Southern Branch : Technical College, Southampton, Joint meeting with the Southern Branch of the Royal Institution of Naval Architects, " Naval Concepts in Marine Transport," P. R. Crew, 7.30 p.m.

Tues., March 28.—North East Coast Section : Stephenson Building, King's College, Claremont Road, Newcastle upon Tyne, " Materials for Advance Steam Conditions and their Influence on Operation of Turbines and Boilers," H. E. C. Hims, and S. H. Frederick, 6.15 p.m.

INSTITUTE OF METALS

Tues., April 4.—Oxford Local Section : Cadena Café, Cornmarket Street, Oxford, Annual General Meeting, and " Ductile Fracture," R. W. K. Honeycombe, 7.15 p.m.

INSTITUTE OF PETROLEUM

Wed., April 5.—61, New Cavendish Street, London, W.1, " Airborne Techniques in Petroleum Exploration," W. Domzalski, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Thurs., March 30.—Northern Centre : Victoria and Station Hotel, Preston, " Road Safety," 7.30 p.m.

Wed., April 5.—Western Centre : Vineyard Restaurant, Colerne, Annual General Meeting, 7 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Tues., March 28.—North Western Branch : Chemical Engineering Lecture Theatre, Manchester College of Science and Technology, Jackson Street, Manchester, " Temperature Control of Exothermic Reactions Entailing Special Heat Transfer Problems," B. F. Street, 6.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Thurs., April 6.—Great George Street, Westminster, London, S.W.1, " River Utilisation and the Preservation of Migratory Fish Life," G. Baxter, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., March 27.—North-Eastern Centre : Neville Hall, Newcastle upon Tyne, " Technical and Economic Aspects of the Supply of Reactive Power in England and Wales," W. Casson and H. J. Sheppard, 6.30 p.m. ★ South Midland Electronics and Measurement Group : James Watt Memorial Institute, Great Charles Street, Birmingham, " New Amplifying Techniques," C. W. Oatley, 6 p.m. ★ Western Utilisation Group : South Wales Institute of Engineers, Park Place, Cardiff, " Some Notes on the Electrical Requirements of General Cargo Docks," E. R. Radway, 6 p.m.

Tues., March 28.—South-East Scotland Sub-Centre : Carlton Hotel, Edinburgh, " The Potentialities of Artificial Earth Satellites for Radio-communication," W. J. Bray, 7 p.m.

Wed., March 29.—Sheffield Sub-Centre : Grand Hotel, Sheffield, " Technical and Economic Aspects of the Supply of Reactive Power in England and Wales," W. Casson and H. J. Sheppard, 6.30 p.m.

Tues., April 4.—South-East Scotland Sub-Centre : Carlton Hotel, Edinburgh, " A General Theory of Depreciation of Engineering Plant," D. Rudd, 7 p.m.

Wed., April 5.—Bedfordshire Sub-Centre : Swan Hotel, Bedford, " An Engineering Project in India," H. E. Knight, 7 p.m. ★ Tees-side Sub-Centre : Cleveland Scientific and Technical Institution, Middlesbrough, " Short-Circuit Ratings for Mains Cables," G. S. Buckingham, 6.30 p.m. ★ Southern Centre : Main Hall, College of Technology, Portsmouth, Annual General Meeting, and Third Hunter Memorial Lecture, " The Application of Electronics to the Electricity Supply Industry," J. S. Forrest, 6.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, March 24.—Northern Ireland Graduates' Section : International Hotel, Belfast, " Human Problems in Marine Engineering," C. C. Pounder, 7 p.m.

Sat., March 25.—London Graduates' Section : Visit to British Internal Combustion Engine Research Association, 9.30 a.m.

Mon., March 27.—Internal Combustion Engines Group : 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on " Is Fuel Injection Equipment Standardisation Limiting the Development of Small Diesel Engines," opened by L. Waters, 6 p.m.

Tues., March 28.—South Wales Branch : South Wales Institute of Engineers, Park Place, Cardiff, Annual General Meeting, and " The Diesel Engine in Association with the Gas Turbine," E. Chatterton, 6 p.m. ★ Birmingham A.D. Centre : James Watt Memorial Institute, Great Charles Street, Birmingham, Annual Meeting, and " Instrumentation Problems of Internal Combustion Engine Development," J. G. G. Hempson, 6.30 p.m. ★ Western A.D. Centre : Royal Hotel, Bristol, " Test Technique Employed in the Application of Carburettors to Vehicle Engines," C. G. O'Neill, 6.45 p.m. ★ Coventry Graduates' A.D. Section : Visit to Courtaulds, Ltd., Foleshill Road, Coventry, 7 p.m.

Wed., March 29.—Ordinary Meeting : 1, Birdcage Walk, Westminster, London, S.W.1, " An Experimental Study of the Flow Conditions and Pressure Drop of Steam-Water Mixtures at High Pressures in Heated and Unheated Tubes," R. W. Haywood, G. A. Knights, G. E. Middleton, and J. R. S. Thom, 3.30 p.m. ★ Eastern Graduates' Branch : Old Manor House, St. Margarets Green, Ipswich, Film Show, 7.30 p.m. ★ Southern Branch : Lecture Theatre, Technical College, Basingstoke, " The Development of Multi-Fuel Engines," G. K. Martlew, 7.30 p.m.

Thurs., March 30.—Easter Branch : Diocesan Hall, Ipswich, " Common and Uncommon Causes of Failure of Plant in Service," G. A. Cottell, 7.30 p.m. ★ East Midlands Branch : Technical College, Lincoln, " Powder Metallurgy Applications," B. H. Swan, 7.15 p.m.

INSTITUTION OF PLANT ENGINEERS

Tues., March 28.—Glasgow Branch : Scottish Building Centre, 425, Sauchiehall Street, Glasgow, C.2, " Recent Developments in Handling and Firing of Domestic and Industrial Boiler Plants," R. Clelland, 7.15 p.m. ★ South Wales Branch : South Wales Institute of Engineers, Park Place, Cardiff, Branch Annual General Meeting, and " Some Engineering Problems with Chemical Plant," J. C. Veale, 6.30 p.m.

Thurs., March 30.—Sheffield and District Branch : Grand Hotel, Sheffield, " The Role of the Central Engineering Workshop in the Maintenance Problem," G. C. Oram, 7.30 p.m.

Tues., April 4.—Peterborough Branch : White Lion Hotel, Church Street, Peterborough, " Factory Electrical Distribution Systems," J. H. Quick, 7.30 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Mon., March 27.—North Midlands Region : Louis Room, St. James's Restaurant, St. James's Street, Derby, Annual General Meeting and Film Show, 7 p.m. ★ North Western Region : Reynolds Hall, Manchester College of Science and Technology, Manchester, Annual General Meeting, and " Electrified Railway Freight Handling Systems," G. R. Higgs, 6.30 p.m.

Tues., March 28.—Luton Graduate Section : Luton College of Technology, Room 233, Park Square, Luton, Annual General Meeting, 7.30 p.m.

Wed., March 29.—Midlands Region : New Technical College, London Road, Shrewsbury, Annual General Meeting and Films, 6.45 p.m. ★ North Western Region : Exchange Hotel, Tithebarn Street, Liverpool, 1, Annual General Meeting, and Film Show, 7.30 p.m.

Thurs., March 30.—North Midlands Region : Ruston Club, Lincoln, Annual General Meeting, 7.30 p.m. ★ Midlands Region : Star and Garter Hotel, Victoria Street, Wolverhampton, Annual General Meeting, and " Modern Trends in Metal Removing Techniques," J. Cherry, 6.45 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Mon., March 27.—Engineer's Club, Albert Square, Manchester, " Extrusion Productivity," T. J. Daniel, 6.45 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

To-day, March 24.—Midland Counties Branch : Byng Kenrick Suite, College of Advanced Technology, Gosta Green, Birmingham, 6, " Models for Design and Research in Reinforced Concrete," G. Brock, 6.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, March 24.—Pepys House, 14, Rochester Row, London, S.W.1, " A New Theory of the Origin of the Planetary System," R. O. Kapp, 7 p.m.

Wed., April 5.—Midland Section : James Watt Memorial Institute, Great Charles Street, Birmingham, " The Words of an Engineer," W. K. V. Gale, 7 p.m.

NEWCOMEN SOCIETY

Wed., April 5.—Science Museum, London, S.W.7, " The Windmills of Derbyshire, Leicestershire and Nottinghamshire : Part I, Post Mills," P. H. J. Baker and Rex Wailes, 5.30 p.m.

NORTH EAST COAST INSTITUTON OF ENGINEERS AND SHIPBUILDERS

To-day, March 24.—Lecture Theatre, Mining Institute, Neville Hall, Newcastle upon Tyne, " Fuel Cells," H. H. Chambers, 6.15 p.m.

REINFORCED CONCRETE ASSOCIATION

To-day, March 24.—Midland Counties Branch : Byng Kenrick Suite, College of Advanced Technology, Gosta Green, Birmingham, Joint meeting with the Institution of Structural Engineers, " Models for Design and Research in Reinforced Concrete," G. Brock, 6.30 p.m.

ROYAL AERONAUTICAL SOCIETY

Wed., March 29.—Agricultural Aviation Group : Lecture Theatre, 4, Hamilton Place, London, W.1, " Atomisation," R. P. Fraser, 7 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Sat., March 25.—Mining Surveyors General Meeting : 7, Manor Place, Edinburgh, 3, " Scottish Developments in the Mining Industry," R. McAdam, 9.45 a.m.

ROYAL INSTITUTION OF NAVAL ARCHITECTS

Tues. to Thurs., March 28 *to* 30.—Weir Lecture Hall, 10, Upper Belgrave Street, London, S.W.1, Spring Meeting; Tues., Annual General Meeting, 10.15 a.m.

SOCIETY OF CHEMICAL INDUSTRY

Tues., March 28.—Corrosion Group : Visit to Northern Aluminium Company, Ltd., Banbury, 12 noon to 1.30 p.m., Laboratory Visit to Aluminium Laboratories, Ltd., 2.30 p.m. to 3.45 p.m., Crown Hotel, Banbury, " The Resistance of Aluminium to Supply Waters," H. P. Godard and " Behaviour of Aluminium in Modern Power Station Condensate Water," E. A. G. Croom and D. Hastings, 4 p.m. to 6.30 p.m.

SOCIETY OF ENVIRONMENTAL ENGINEERS

To-day, March 24.—Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2, Annual General Meeting, 2.30 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Tues., March 28.—Control Section : Manson House, 26, Portland Place, London, W.1, " Automatic Optimisation," P. E. W. Grensted and O. L. R. Jacobs, 5 p.m. and " The Development of an Optimising Controller," P. F. Sutherby, 7 p.m.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE

To-day, March 24.—39, Elmbank Crescent, Glasgow, Symposium on " Heat Treatment," 6.45 p.m.